Walter W. Bradley.

ERRATA

Note that pages 245 to 255 are duplicated, because of *supplement* to April chapter, describing "Placers of Southern California."

Mining in California

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

EXECUTIVE AND TECHNICAL STAFF

WALTER W. BRADLEY
State Mineralogist

Olaf P. Jenkins, Chief Geologist - - - - - -	San Francisco
C. A. Logan, District Mining Engineer - - - - -	Sacramento
C. McK. Laizure, District Mining Engineer - - - -	San Francisco
W. Burling Tucker, District Mining Engineer - - - -	Los Angeles
Reid J. Sampson, Assistant District Engineer - - - -	Los Angeles
Chas. V. Averill, District Mining Engineer - - - -	Redding
Frank Sanborn, Mineral Technologist - - - - -	San Francisco
Henry H. Symons, Statistician and Curator - - - -	San Francisco
Herbert A. Franke, Junior Mining Engineer (Librarian) -	San Francisco

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
D. H. BLOOD, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

Vol. 28 — JANUARY, 1932 — No. 1

CHAPTER OF

REPORT XXVIII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1932

TABLE OF CONTENTS

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

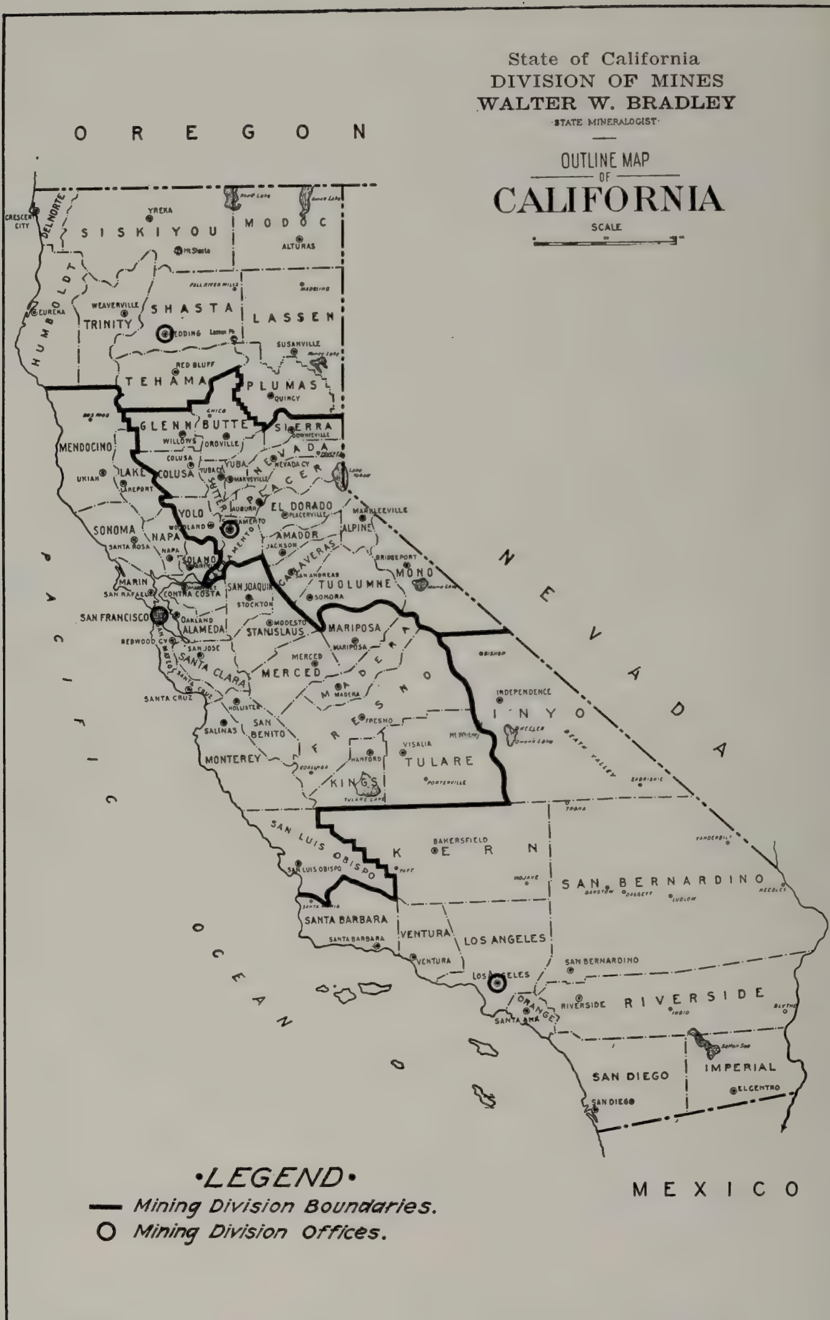
Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.


State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
OREGON
NEVADA
PACIFIC
OCEAN
MEXICO
SISKIYOU
MODOC
DELNORTE
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
SUTTER
NEVADA
PLACER
EL DORADO
ALPINE
SONOMA
NAPA
YOLO
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
MONO
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
FRESNO
INYO
SAN BENITO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
YREKA
ALTURAS
CRESCENT CITY
EUREKA
WEAVERVILLE
REDDING
SUSANVILLE
RED BLUFF
QUINCY
CHICO
WILLOWS
OROVILLE
DOWNIEVILLE
UKIAH
LAKEPORT
COLUSA
NEVADA CY
MARYSVILLE
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
JACKSON
SANTA ROSA
NAPA
BRIDGEPORT
SAN ANDREAS
SAN RAFAEL
STOCKTON
SONORA
OAKLAND
MODESTO
REDWOOD CY
SAN JOSE
MERCED
INDEPENDENCE
HOLLISTER
SALINAS
FRESNO
MADERA
VISALIA
HANFORD
PORTERVILLE
DEATH VALLEY
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XIV to XVII, inclusive, in the case of many of the counties have become exhausted. Beginning with the January, 1925, issue of 'Mining in California,' these have been revised and brought up to date, by presenting the district engineers' reports each in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This county series was completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, was begun in 1931, and will be added to in future issues. Papers by the Geological Branch and other county reports are also included.

REDDING FIELD DIVISION

Chas. V. Averill, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the Redding field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

SACRAMENTO FIELD DIVISION

C. A. Logan, Mining Engineer

Mr. C. A. Logan, District Mining Engineer, is engaged in preparing a special 'Mother Lode' report, and there is no county report in this issue.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

There is no report from the San Francisco Field Division, as the present series of county reports is complete for this district.

LOS ANGELES FIELD DIVISION

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

ECONOMIC MINERAL DEPOSITS OF THE SAN JACINTO QUADRANGLE*

By R. J. SAMPSON, Mining Engineer

Location and Geographic Features.

The San Jacinto quadrangle comprises an area of some 785 square miles in the northwestern portion of Riverside County. It lies between 33° 30′ and 34° 00′ N. latitude and 116° 30′ and 117° 00′ W. longitude and includes Townships 4, 5, 6 and 7 S. and a part of T. 8 S., Ranges 1, 2, 3 and 4 E.; also a portion of R. 1 W., S. B. B. and M. The entire quadrangle is mountainous with the exception of a few square miles in the west center where Bautista Canyon debouches into the San Jacinto Valley and a small area, in the northeastern corner surrounding Palm Springs, in the Coachella Valley.

This quadrangle is bounded on the north by the San Bernardino Mountains, on the east by the Coachella Valley, on the south by Chihuahua Valley and several low ranges of hills and on the west by the San Jacinto Valley.

The most prominent topographic feature of the quadrangle is San Jacinto Peak which rises to an elevation of 10,805 feet and Tahquitz Peak, located about five miles south of San Jacinto Peak which reaches an elevation of 8825 feet.

The region is an arid one, few streams flowing the year around. Drainage to the south and west is into the San Jacinto River which empties into Lake Elsinore. Whitewater River carries the waters from the northeastern slopes, finally discharging them into the Salton Sea.

The central portion of the quadrangle is very sparsely settled but the town of Hemet is within its western boundary while Beaumont and Banning mark its northern edge.

The principal industry is farming.

Mineral Deposits.

No mineral deposits of great commercial importance have been discovered in this area. Perhaps its greatest asset, of this kind, consists of the mineral springs. These are found along the western base of the mountains, following the line of the Hot Springs fault and at the eastern base where Palm Springs probably marks the northern continuation of Palm Canyon fault.

The most interesting deposits as yet discovered in the area consist of gem materials. These deposits were found near the crest of the

* This report is an economic supplement to "Geology of San Jacinto Quadrangle south of San Gorgonio Pass, California," by Donald McCoy Fraser, published in MINING IN CALIFORNIA, October, 1931.

range to the northwest of Coahuila, in the granite, near its contact with the older metamorphic-rock series.

A small production of gold has been made from narrow quartz veins in the vicinity of Kenworthy but as yet nothing of importance has been developed.

A few deposits of feldspar and silica have been found in the pegmatite veins in the granite. Production to date from these has been small.

Some crystalline limestone deposits here found have potential value in that they may be used in the future for the manufacture of cement.

FELDSPAR AND SILICA

Coahuila Brave Feldspar Deposit. C. E. Williamson, 1107 West 56 Street, Los Angeles, has shipped feldspar from a group of 5 claims, 35 miles east of Temecula. These claims are known as Coahuila Brave Nos. 1, 2, 3, 4 and 5. The workings are near the top of Coahuila Peak at an approximate elevation of 5500 feet.

It is reported that there are seven roughly parallel pegmatite dikes in the granite, having an average width of 10 feet. The dikes have a NE-SW strike and dip to the southeast at an angle of about 60°. The feldspar occurs in masses which are enclosed by clear, vitreous quartz. These occurrences are confined to short lenses along the strike of the dikes.

Development consists of a series of open cuts near the top of the mountain. After sorting, the feldspar is taken down the mountain by a low-geared truck and put into a four-ton bin from which a higher geared truck receives it for transportation to the railroad at Temecula.

On account of its isolation and the fact that the property was idle at the time, this deposit was not visited. The above information was given by Mr. Williamson.

Bibl: State Mineralogist's Report XXV, pp. 503–504; XXVII, p. 422.

Hemet Silica Mine is in Sec. 27, T. 5 S., R. 1 W., S. B. M., 3 miles south of Hemet on Polly Butte. It was first worked by the Hemet Silica Company and later by the *San Jacinto Rock Products Company,* G. W. Green, president, San Jacinto, California. Elevation 1850 feet.

The deposit consists of a series of lenses of quartz in a pegmatite dike in granite. Strike N-S, dip 80° to the east.

The principal development is on the northwest slope near the top of the hill. It consists of an open cut 25 feet deep by 50 feet long, exposing about 75 feet of solid quartz. On account of its high iron content, it is classed as second-grade silica. Material was hauled to San Jacinto where this company formerly had a grinding plant. Idle.

Bibl: State Mineralogist's Report XXV, pp. 504–505; XXVII, p. 443.

GEMS

Gem material (tourmaline) was discovered near the crest of the San Jacinto range in 1893. A considerable production of fine red and green crystals resulted from this discovery. The *Columbia, Fano* and

San Jacinto mines were the principal producers. The gems are found in pegmatite dikes in granite. Generally these dikes have a NW-SE strike, dipping flatly to the southwest.

In recent years only the Fano mine has been worked, its production being largely beryl and rose quartz.

The following is taken from California State Mining Bureau Bulletin No. 37, Gems, Jewelers' Materials, etc., pp. 57–59:

"In 1893, near the crest of the San Jacinto range, in Riverside County, loose or 'float' crystals of tourmaline were observed, chiefly black but some finely colored—red, rose, green, blue, etc. In some cases the green crystals were found to have red centers— a type long known from Brazil. Some large crystals were obtained and a number of gems were cut from them. These indications were promptly followed up and several mining claims were located and worked.

"One of these, opened near the summit of the range by three prospectors, Messrs. Dwight Whiting, F. M. Speer and F. H. Jackson, was called by them the San Jacinto gem mine. It was reported that more than a bushel of red and green crystals was found during the first season's operation, one of which measured eight inches in length and several inches in diameter. This was purchased by Harvard University, with other crystals several inches long and two inches in diameter. One of this size had a dark green basal termination and showed a red center on the fracture at the other end of the crystal. Other very fine ones are in the American Museum of Natural History, at New York. Elegant specimens were made by cutting and polishing sections across the prism, in some large crystals of this type, showing the rich green exterior, then a narrow zone of white and within that the red central portion—a beautiful contrast of colors, recalling a slice from a watermelon. Some of these were as much as three inches in diameter. A few years later, remarkably fine crystals of colorless tourmaline (achroite) were reported from this locality by Mr. Dwight Whiting.

"Soon there were several mines in operation in the San Jacinto district and these gave quite a valuable output for many years. At present the one that is most prominent is that known as the Fano (formerly the Simmons) mine, discovered in 1902 by Mr. Bert Simmons but now owned by Mr. E. A. Fano, of San Diego, This is located on the north side of Coahuila Mountain, at an altitude of some 4500 feet, about a mile south of Bautista Creek and four miles west of Ramona Indian reservation. About the same distance east of the reservation and a little south on Thomas Mountain at 5000 feet elevation, is the site of the original discovery of colored tourmalines in this county made by Mr. Hamilton in 1872. This has been known as the Columbia gem mine and has yielded very fine material; but it has not been worked much of late years, owing to litigation, other parties claiming it under the name of the April Fool mine.

The Fano mine, besides colored tourmalines, especially rich shades of blue and green, yields some beryl and a little kunzite, with lepidolite and amblygonite. Its structure is typical of the gem deposits of southern California—a ledge consisting of a vein (or dike) of pegmatite, about five feet thick, with a northwest and southeast course and a dip of 17° to the southwest. The inclosing rock is called a blue granite, but is probably the diorite (or gabbro) rock."

GOLD

Gold Shot Mine, comprising about 800 acres, is in Secs. 28, 29 and 33, T. 6 S., R. 4 E., S. B. M., in the San Jacinto Mountains, about 35 miles southeast of Hemet. Elevation 5000 feet. Owner, Gold Shot Mines, Inc., Carl J. Christensen, president; Albert Christensen, secretary, both of Garden Grove, California.

The property is in Bull Canyon, which here has a general N-S trend. The western side of the canyon is all typical granite, with the exception of a comparatively narrow lens of limestone which outcrops near the head of the canyon. The east side is granite and limestone.

A series of narrow quartz stringers occur in the granite, on the west side of the canyon. Strike nearly E-W, dip about 65° to the north. On one of these a tunnel has been driven westerly a distance of about 70 feet. The quartz exposed is from 2 inches to 6 inches wide. At the mouth of this tunnel a shaft has been sunk on the vein to a reported depth of 90 feet. At the 50-foot level a drift was run west 100 feet and a stope about 25 feet long has been worked up through the floor of the tunnel. Width of stope is about 2½ feet. On a roughly parallel vein about fifteen hundred feet up the canyon, a shaft 25 feet deep has been sunk.

On the east side of the canyon an open cut has been made in the gneissoid margin of the granite. This cut has exposed some 15 or 20 feet of black and red hematite in which it is reported occasional coarse pieces of gold are encountered. The belt in which this hematite occurs is some 70 to 100 feet wide and is traceable in a N-S direction for more than a mile.

Equipment consists of 15-stamp Straub mill; one 4-ft. by 4-ft. amalgamating plate; 200-cu. ft. compressor driven by 35-h.p. gasoline engine; 9-h.p. gasoline hoist; and 15-h.p. engine to run the mill.

Water is obtained from a spring in the canyon. Idle at time of visit.

Hemet Bell Mine is in Sec. 31, T. 6 S., R. 4 E., S. B. M. It is about 33 miles east of Hemet. Elevation 5000 feet. Owner, E. E. Chilson Estate, Kenworthy, California.

This mine has not been worked for several years, although it is reported that some prospecting has recently been done. It is reported that quartz veins 6 inches to 8 inches wide here occur in granitic gneiss. Average value of the ore was reported as $15 to $20, with some high values occurring in pockets.

Ore was treated in a 5-stamp mill, water for which was obtained from a mountain spring. Idle.

Bibl: State Mineralogist's Report XV, p. 535; XXV, p. 481.

LIMESTONE

Eden Hot Springs Limestone Deposit is in Sec. 23, T. 3 S., R. 1 W., S. B. M., just east of Eden Hot Springs, on the western slope of the San Jacinto range of mountains, about 10 miles northwest of San Jacinto. Owner, Eden Hot Springs, Inc.

The strike of the deposit is northwest and southeast. The limestone is white in color, coarsely crystalline and reported to be 98% calcium carbonate. Idle.

Bibl: State Mineralogist's Report XXV, p. 515.

Guiberson Deposit (Whitewater). This property is located in the SE¼ of Sec. 22 and the SW¼ of Sec. 23, T. 3 S., R. 3 E., S. B. M., one-half mile south of Whitewater, a station on the Southern Pacific Railroad. Holdings comprise 160 acres, patented. Elevation 1200 feet. Owner, S. H. Guiberson, Los Angeles.

The Whitewater limestone contains occasional intrusions of diorite, probably offshoots from the Jurassic batholith forming the San Jacinto Mountain. The rock contains some hornblende, very little mica and subordinate amounts of quartz. The limestone belongs to the Carboniferous age. The bedding planes of the limestone dip S. 42° to 65° W., and the strike is N. 30° to 40° W. Back of the belt of limestone there is a stratum of mica schist which dips 65° SW. The thickness varies from 8 to 20 feet. On the mica schist contact there is a zone of soda-lime feldspar, with a high silica content, classified as quartz-diorite. The limestone deposit varies in width up to 200 feet and lies against the diorite of the San Jacinto batholith. Estimated quantity of limestone is 100,000,000 tons.

Development consists of three tunnels driven south from the San Gorgonio wash and a number of opencuts.

Analysis of limestone is as follows:

	Per cent
Silica (SiO_2)	0.74
Alumina (Al_2O_3)	0.004
Iron (Fe_2O_3)	0.008
Lime (CaO)	53.29
Magnesia (MgO)	2.39

Idle.

Bibl: State Mineralogist's Report XXV, pp. 515–516.

Hubbard Limestone Deposit is in T. 3 and 4 S., R. 1 W., 4 miles northwest of San Jacinto, at an elevation of 2600 feet. It is just east of the road from Soboba Hot Springs to Gilman's Relief Hot Springs. Owner, Omar H. Hubbard, Hubbard Building, Long Beach, California.

This property was formerly owned and operated by the *Snowflake Lime Company*. It was equipped with a steel-shell lime kilm which is still on the property. The strike of the deposit is N. 40° W. and the dip is about 18° to the northeast. It is crystalline limestone of a very good grade. This is probably part of a deposit which outcrops intermittently from this point, in a northwesterly direction, to a point in Coyote Pass.

Approximately one thousand feet above the road, in the head of a very steep canyon, an open cut has been made in the limestone. This cut now presents a face 20 feet high by 75 feet long. The broken rock was allowed to roll down the canyon to the kiln. Idle.

Moore Limestone Deposit is in T. 6 S., R. 1 E., S. B. M., in Bautista Canyon, 11½ miles east of Hemet. Owner, J. S. Moore, Winchester, California.

This limestone outcrops in Bautista Canyon for a distance of about 2 miles and apparently is about 30 feet wide. The strike is NW. and the dip is 50° to 60° to the southwest. It is finely crystalline and the color is white to blue. The Moore deposit has been opened by a quarry some 50 feet long by 20 feet in height. The rock rolls down the hill to the top of an inclined tram where it is loaded into cars and lowered to the level of the road. Idle.

Bibl: State Mineralogist's Report XXV, p. 516.

Novelle Limestone Deposit is situated in Sec. 26, T. 3 S., R. 3 E., S. B. M., 2 miles south of Whitewater. Holdings comprise 640 acres. Owner, George A. Novelle, Monrovia, California.

The stratum of limestone is about 500 feet in thickness, strikes N. 40° W. and dips 40° to the southeast. The limestone is cut by intrusions of diorite. On the west side of the deposit there is a narrow belt of mica-schist which strikes N-S and dips 40° E. The belt can be followed along its outcrop which attains a height of 500 feet above the plane of the valley for a distance of twenty-five hundred feet southeasterly to the wash of Blaisdell Canyon. The limestone is blue to gray in color and coarsely crystalline. Idle.

San Jacinto Rock Products Company's Deposit is in Bautista Canyon, 12 miles east of Hemet. It is on the south side of the canyon and is a continuation of the belt in which the Moore deposit is located. Elevation 2000 feet. Owner, San Jacinto Rock Products Company; G. W. Green, president, San Jacinto, California.

This limestone is crystalline and white to blue in color. The deposit has a northwesterly strike and dips at an angle of 40° to the southwest. Its outcrop between granite walls is traceable for about one-half mile. The average thickness is about 30 feet. The present quarry is a sidehill cut, having a face 30 feet high by 100 feet long. The rock from the quarry was loaded into trucks and hauled to the company's grinding plant in San Jacinto. The product was used for chicken feed. Idle.

Southern Pacific Company's Limestone Deposit is in Secs. 23 and 25, T. 3 S., R. 3 E., S. B. M., one mile south of Whitewater, a station on the Southern Pacific Railroad. Elevation 1500 feet. Owner Southern Pacific Company.

The beds of crystalline limestone contains numerous intrusions of diorite and strata of mica-schist from 8 to 20 feet thick. The limestone is from 400 to 600 feet thick. The rock is coarsely crystalline and it is reported that it is 98% calcium carbonate. The belt of limestone strikes northwest, coursing through Secs. 23, 24 and 25, T. 3 S., R. 3 E. It is parallel to the stratum of limestone on the Guiberson deposit. Undeveloped.

MINERAL SPRINGS

The curative properties of the mineral springs of this area have long been recognized and many people are thereby attracted to the hotels which are operated in connection with them.

By reason of its intensive development and an elaborate construction program which, in recent years, has been carried out, Palm Springs is now the most widely known resort in this area.

Gilman Hot Springs. These springs formerly known as *San Jacinto* or *Relief Hot Springs,* are situated at the base of the mountains in the northern edge of the San Jacinto Valley, about 5 miles northwest of the town of San Jacinto. Owned by the Gilman family, W. E. Gilman, manager, San Jacinto, California.

Some half dozen springs here issue from a bank of granitic alluvium and form a marshy area several acres in extent.

This has been a resort for many years. A large hotel and some cottages in a grove adjacent to the springs furnish accommodations for patrons, while swimming pool, tennis courts and golf links have been provided for their pleasure. Besides the tub baths there are mud baths that use material from the tule marsh.

The following is quoted from United States Geological Survey Water Supply Paper 338, p. 38:

"The waters are sulphureted and they also taste distinctly alkaline. Efflorescent alkaline salts form in small amounts on the banks beside the springs and the iron and sulphide contents cause the water to stain the towels and enameled tubs. The following partial analysis of the water that is used chiefly for bathing shows the general character of the water, though the several springs differ somewhat in chemical characteristics:

"Analysis of water from Black Springs, San Jacinto Hot Springs, Riverside, Co., Cal. (Analyst, E. W. Hilgard (?). Authority, advertising matter. Constituents are in parts per million.)

Properties of reaction:	
Primary salinity	Dominant
Secondary salinity	(?)
Tertiary salinity	0
Primary alkalinity	(?)
Secondary alkalinity	Prominent
Tertiary alkalinity	Present
Residue:	
Soluble in water	3,770
Insoluble in water	2,120
	5,890
Portion soluble in water:	
Sulphate (SO_4)	366
Chloride (Cl)	1,920
Carbonate (CO_3)	30
Metaborate (BO_2)	Trace
Nitrate (NO_3)	Trace
Sodium and potassium (Na+K), chiefly sodium	1,454
Portion insoluble in water:	
Silica (SiO_2)	20
Calcium (Ca), magnesium (Mg), carbonate (CO_3), and sulphate (SO_4), chiefly calcium	2,100
Hydrogen sulphide (H_2S)	Present

"The analysis indicates that the water is highly concentrated, is chiefly primary saline in character, and has secondary alkalinity as a prominent property. The water is unsuited for industrial or agricultural use."

Palm Springs. The Palm Springs are situated at the eastern base of San Jacinto Peak on the western edge of Coachella Valley and were formerly known as *Aguas Calientes.* Owner, United States Government.

The water emerges at a temperature of 100°. This fact and the general topography of the country would seem to indicate that the springs are on a fault line. The following analysis is taken from United States Geological Survey Water Supply Paper 338, p. 40:

"Analysis of water from Palm Springs, Riverside Co., Cal.

(Analyst, Oscar Loew, Wheeler report (1876). Constituents are in parts per million.)

"Temperature	38°C. (100°F.)
Properties of reaction:	
Primary salinity	77
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	23
Secondary alkalinity	Trace
Tertiary alkalinity	?

CONSTITUENTS

	By weight	*Reacting values*
Sodium (Na)	158	6.87
Lithium (Li)	Trace	Trace
Calcium (Ca)	Trace	Trace
Magnesium (Mg)	Trace	Trace
Sulphate (SO_4)	Trace	Trace
Chloride (Cl)	188	5.30
Carbonate (CO_3)	47	1.57
Silica (SiO_2)	Trace	Trace
	393	---
Hydrogen sulphide (H_2S)	Trace	Trace"

In the last few years construction of several first-class hotels and a number of cottages, golf links, swimming pools, etc., has made this one of the leading winter resorts of southern California.

Soboba Hot Springs. These springs formerly known as *Ritchey Hot Springs* are about 3 miles northeast of San Jacinto. John G. Althouse, San Jacinto, California, is the owner and manager.

Here six springs, ranging in temperature from 70° to 111° issue from the side of a ravine at the base of the mountain.

In a tunnel driven into the hillside a temperature of 82° was registered. This was formerly used as a sweat chamber. Gypsum and efflorescent alum salts form on its walls and indicate that the tunnel water may be mineralized to a notable extent by acid constituents.

The following is quoted from United States Geological Survey Water-Supply Paper 338, pp. 39 and 40:

"Analysis of water from 'lithia' spring at Ritchey Hot Springs, Riverside County, Cal. (Analyst, L. J. Stabler. Authority, advertising matter. Constituents are in parts per million.)

Properties of reaction:	
Primary salinity	44
Secondary salinity	0
Tertiary salinity	0
Primary alkalinity	54
Secondary alkalinity	2
Tertiary alkalinity	18

CONSTITUENTS	*By weight*	*Reacting values*
Sodium (Na)	55	2.37
Potassium (K)	71	1.81
Lithium (Li)	Trace	Trace
Calcium (Ca)	1.7	.08
Magnesium (Mg)	Trace	Trace
Iron (Fe)	Trace	Trace
Aluminum (Al)	Trace	Trace
Sulphate (SO_4)	52	1.08
Chloride (Cl)	28	.79
Carbonate (CO_3)	72	2.40
Silica (SiO_2)	23	.76
	302.7	---

"Primary alkalinity is the dominant property, and its high percentage is specially noteworthy. Primary salinity and tertiary alkalinity are also prominent, though the latter is not fully reported. The relatively high proportion of potassium is unusual and in the absence of confirmation by other analyses should not be given weight.

"The ravine in which these springs issue is steep, with narrow, precipitous sides, and the rock exposed is largely a crushed gneiss. Recent landslide patches within it also indicate the broken and disturbed character of this area and furnish local evidence that the thermal character of the springs is due to crushing and slipping of the rocks."

Desert Inn, Palm Springs, California.

Palm Canyon, Palm Springs, California.

Palm Springs, California.

GEOLOGIC BRANCH

CONTRIBUTIONS TO THE STUDY OF SEDIMENTS

By Olaf P. Jenkins, Chief Geologist

With the progressive development of nonmetallic industries, comes a constant demand for more accurate technical information of the fundamentals of the science employed. Sediments and sedimentary rocks are involved in most of the larger nonmetallic industries. For example, the mineral fuels are all found in this class of rocks. Many of the products used in the most extensive construction programs are of this origin; for instance, materials such as sand, clay, and limestone are sediments and they are all used in vast quantities.

It is quite in order, therefore, that we examine with extreme care the composition, origin, and history of these materials. No better place for such examination exists than at the original place of deposition.

In this issue of Mining in California there are two significant papers on sedimentation: The first, entitled "Geology and Physical Properties of Building Stone from Carmel Valley, California," deals with a stratified rock formation, which was originally a soft organic sediment lying on the bottom of the ocean, but has since been elevated, tilted, and hardened into its present form. The second, as the title implies, "Sediments of Monterey Bay, California," has to do with recent deposits which have been laid down and even now are being formed not only on the sea floor as marine sediments, but along the shore as dunes.

In the first paper a practical classification of local building stone is presented, based on both commercial utility and laboratory tests. Types of the stone are thus standardized. To the quarryman and the architect this paper should be of particular value.

In the second paper a most careful scientific study is presented to reveal the nature and mode of deposition which is going on at the present time in Monterey Bay. Both physical and chemical aspects of the problem are given, representing the result of an examination of dredged samples taken from the sea floor. Fundamental principles are thus formulated and definite knowledge is graphically recorded.

The oil geologist should welcome this information, for it should better equip him with data for use in correlation of well logs. More accurate interpretation of geologic phenomena may thus also be gained.

In development of the sand industry and in prospecting in other areas than about Monterey Bay for this product, assistance should be found by application of the principles set forth in the discussion.

The Geologic Branch of the California State Division of Mines is greatly indebted to Mr. E. Wayne Galliher for his generous cooperation in the preparation of these articles. His paper on the Carmel Valley building stone represents the results of one of the projects of

research done under the auspices of the Geologic Branch of the Division of Mines. His discussion on recent sediments of Monterey Bay, however, is entirely a contribution by him, representing some months of research carried on at the Hopkins Marine Station and at Stanford University. The results of this research will only be fully appreciated after its application is extensively made in various lines of work. So far as we know, this is the first time that a detailed geological or rather lithological map has ever been accurately constructed of an area of the sea-bottom on the Pacific coast.

GEOLOGY AND PHYSICAL PROPERTIES OF BUILDING STONE FROM CARMEL VALLEY, CALIFORNIA

By E. Wayne Galliher*

OUTLINE OF REPORT

*Part-time geologist, Geologic Branch, California State Division of Mines.

Introduction.

With but few exceptions the siliceous shale units occurring in California's sedimentary column have been studied in relation to the origin and accumulation of oil. The vast amount of data pertaining to these shales is thus concerned mainly with their stratigraphy and the correlation.

From such studies but very little data have come which are of value for the commercial development of these siliceous sediments as

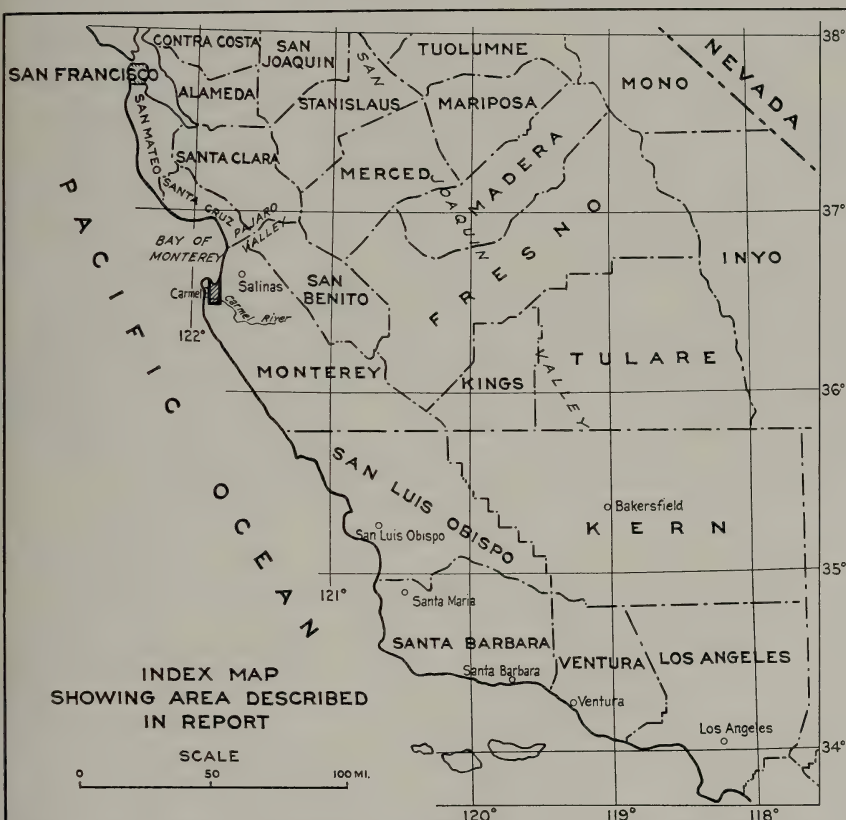


FIG. 1. The shaded portion indicated on this index map represents the southern central part of the Monterey quadrangle.

architectural stones. It is the purpose of this report to supply certain information pertaining to the geology and physical properties of the shale and sandstone which are being quarried for use as building stone in the vicinity of Carmel, California. These architectural stones, variously known as 'Santa Lucia stone,' 'Carmel stone,' 'Monterey stone,' and 'chalk-rock' belong to one of the major siliceous shale units in California, namely the Monterey formation.

Some misconceptions have arisen in the past as to the type of deposit to which the rock belongs. An instance of this is the common use of the term 'chalk-rock'—a gross misnomer—for the sediment has but few similarities to sedimentary chalk. The chief differences, which are chemical and biological, will be emphasized later.

In the past, because of rapid exploration and careless grading of products, there have been completed a number of jobs in which stone of inferior quality has been used. As a result, this architectural rock has received some adverse criticism and advertising. It must be admitted that the number of uses of the shale and sandstone are not unlimited. However, intelligent specification, selection, and use of the various grades should be expected if the buyer is at all familiar with their general properties.

Object of the Report.

In this report a rational classification of the stones into various types is attempted, along with a discussion of the various uses to which these types have been put. Some suggestions for further use of the stones are made. The commercial development of these particular types of architectural stones is as yet in an embryonic stage; hence it is impossible to exercise too much caution in selecting and advertising the different grades.

The information pertaining to the general geology and positions of the grades of rock in the sedimentary column should aid in its further development. The rather wide distribution of these unique architectural stones in the State makes the commercial possibilities of high potential value.

Since the object of the report has been to assist in the economic development of the building stone, the writer has attempted to give a non-technical discussion of the geological principles.

Acknowledgments.

The writer is indebted to the quarrymen of Carmel, California, and especially to Mr. John Bathen of the Santa Lucia Quarries, Ltd., for his interest in the project. Thanks are due Mr. Charles Moser for the use of the compression-testing machines of the Engineering Department, Stanford University. The writer is also indebted to Mr. H. W. Furlong for suggestions and criticisms.

Some data pertaining to the areal geology of the district have been obtained from the geological map of the Monterey quadrangle by Carl H. Beal to which reference is later made in this report.

The examination upon which this report is based was made possible through the cooperation of the Geologic Branch of the California State Division of Mines.

GEOLOGY

General Considerations.

The rocks reported on here belong to a large class known as sedimentary; that is, the rocks are bedded and have been formed by the deposition of débris derived from older rocks and by the accumulation of variable amounts of the more or less unaltered remains of plants and animals. In this particular case these various kinds of débris were

accumulated in a marine basin, and the material was of such a nature that it formed a highly siliceous, chemically resistant kind of sediment. In certain portions of the basin, diatoms[1] contributed largely to sediments accumulating on the sea bottom. The subsequent uplift and hardening of these bottom sediments has brought them to their present position and given them their lithologic characteristics.

Age of the Rocks.

Earth history has been divided into several well-known time units the relative ages of which have been designated, but the exact ages of which, in terms of years, are not definitely known. The following table indicates the relative position of some of these time units and gives their range in years as estimated in the most recent compilation of data:[2]

Geologic time divisions of the Cenozoic era		*Approximate age in years; estimate based on radio-activity*
Recent		Present time
Quaternary		1 million years
Tertiary	Pliocene	7 million years
	Miocene	19 million years
	Oligocene	35 million years
	Eocene	35 million years

Since the rocks with which this report is concerned were deposited in approximately middle Miocene time, they may be said to be somewhere between 20 and 22 million years old. The above table concerns only the latest of the four great eras in geologic time (the other three being the Mesozoic, Paleozoic, and Proterozoic). Only a portion of the earth's time units is, therefore, represented by the strata described in this report. The age of these strata, geologically speaking, may be considered relatively recent when it is realized that the total age of the earth (using radioactivity as a basis for computation) has been placed at 1,240,000,000 to 1,710,000,000 years.

General Character.

Although the formation to which the architectural stones belong may be fairly easily recognized by its distinctive lithology, there occur within the unit variations in types which give it considerable commercial value.

In general, the rock is unique in consisting largely of opal, a form of hydrated silica. In some places the rocks have suffered secondary alteration and the opal has been changed to chalcedony, a less hydrous and harder form of silica. In certain localized areas there are admixtures of clay and sand; in others, strata with high lime content (calcareous types) prevail. In fact, some parts of the formation may be designated limestones since their carbonate contents range as high as 80 per cent.[3] These occurrences are in the minority for the most part, but they are sufficiently common to give the formation considerable variation.

---

[1] Diatoms are very minute, single-celled plants which secrete shells, or tests, of hydrous silica-opal, the chemical formula of which is usually expressed as $SiO_2(H_2O)$; upon death, the empty shells may subside to the bottom. Water, H_2O, may reach 10 per cent.

[2] Wilmarth, M. G., The geologic time classification of the United States Geological Survey compared with other classifications: U. S. Geol. Survey Bull. 769, p. 5, 1925.

[3] Analyses made by the author.

Few chemical analyses have been made of the lithologic types to which the building stones belong, but those published show an average silica content of approximately 85 per cent.[4]

Certain portions of the formation are extremely diatomaceous; that is, the rocks in these parts are composed to a large degree of the opaline shells of diatoms or the fragments of such shells. In these cases the recognizable diatom débris may make up as much as 75 per cent of the volume of the rocks. Such types are usually soft, however, and the harder, denser phases show few, if any, remnants of diatom shells. In some cases shells have been dissolved and the opal reprecipitated leaving only an amorphous groundmass. In fact, it is hard to designate any one sample of the 'Monterey shale' formations as 'typical.'

General Distribution.

The building stones covered in this report belong to a formation or formations of considerable importance in the Tertiary column of California. The main areas in which these units occur have been called the Ventura, Los Angeles, Santa Maria, San Joaquin, and Salinas basins. These units, if such they may be called, interfinger and overlap and are somewhat difficult to correlate exactly. Grant and Gale[5] have recently given a generalized correlation table of the Monterey and associated formations and discussed the sedimentation problems connected with such a study. R. M. Kleinpell[6] is attempting a more exact correlation of the middle Miocene siliceous formations by means of a micropaleontologic study. These correlations are important here in emphasizing the fact that California possesses a widely distributed group of siliceous sediments of considerable importance as nonmetallic products.[7] The physical and chemical properties of many of these are only partly known in detail.

Conditions of Formation.

The above named basins (the Ventura, Los Angeles, San Joaquin, and Salinas) were recipients of the siliceous sediments during middle Miocene time. The Carmel Valley area was part of the more extensive Salinas basin. Anderson and Martin[8] called this the Temblor basin and gave a general idea of the type of geography of that time. A picture of that ancient physical geography may be gained by imagining the Salinas, Carmel, and Pajaro valleys as covered with one connected body of marine water of fairly shallow depth, probably less than 1000 fathoms. The other areas mentioned were also sites of inland seas.

These seas were outlined by land masses, largely of insular and peninsular character. Remaining to the present are rather well-

---

[4] See the following for more complete data: Davis, E. F., The radiolarian cherts of the Franciscan group: Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, pp. 278-304, 1918. Arnold, Ralph, and Anderson, Robert, Geology and oil resources of the Santa Maria oil district, California: U. S. Geol. Survey Bull. 322, p. 45, 1907.

[5] Grant, U. S. IV, and Gale, H. R., Pliocene and Pleistocene Mollusca of California: Mem. San Diego Soc. Nat. Hist., vol. 1, p. 31, 1931.

[6] Manuscript in preparation.

[7] For a description of other California siliceous formations see Tolman, C. F., Biogenesis of hydrocarbons by diatoms: Economic Geol., vol. 22, no. 5, p. 457, 1929.

[8] Anderson, F. M., and Martin, Bruce, Neocene record in the Temblor basin, California, and Neocene deposits of the San Juan District, San Luis Obispo County: Proc. Calif. Acad. Sci., 4th ser., vol. 4, pp. 15-112, 1914.

preserved remnants of these ancient islands and peninsulas. For instance, in the Salinas basin Mount Toro was probably an island, the Santa Lucia Range a peninsula, while the La Planza, Gabilan, and Palo Escrito ranges were also land areas of that time.

It is generally agreed that this middle Miocene or Monterey sea was fairly shallow.[9] Reed [10] has placed the depth at somewhere between 1000 and 5000 feet and suggested that the land areas which existed during the time of deposition of the siliceous sediments were, in general, of low relief.

The Monterey Sediments.

It is a general law of sedimentation that near-shore deposits are of coarse material, such as sand and gravel, while the off-shore deposits become progressively finer as depth of water and distance from the shore line increase. Different facies, which are merely different areas in a basin of deposition, are often characterized by differences in lithology as represented in the accompanying diagram.

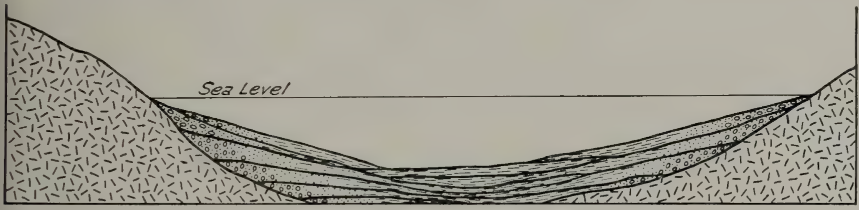


FIG. 2. Diagram to illustrate progressive gradation from coarse near-shore sediments to fine material far from shore as laid down under water in a basin of sedimentation. Diagrammatic, with vertical scale very exaggerated.

In the case of the Monterey sediments where they lap against the old land mass, their character changes. They usually become denser, contain more clastic material in proportion to opaline matrix, and become structurally different stones. A study of the facies represented is of considerable importance, for the texture, as well as other physical properties, of the building stones has been determined largely by the facies in which they were deposited.

Those beds which were deposited at some distance from the shore line are more homogeneous for a given part of the section. This homogeneity is the result of the rather constant proportions of clay and silica cement. The origin of this opaline cementing material which forms such an important constituent of the Monterey sediments is not definitely known, but it is not amiss to review here the important theories which pertain to the question.

Fairbanks[11] proposed that the sediments were the result of the silicification of diatomaceous shales and that this alteration was effected before the deposition of the next overlying formation. Davis,[12] however, says:

> "The Monterey cherts appear to have been laid down in the form of gelatinous silica. Evidence has been presented to show that they were not

[9] Tolman, C. F., *op. cit.* pp. 459–461.

[10] Reed, R. D., The post-Monterey disturbance in the Salinas Valley, California: Jour. Geology, vol. 33, no. 6, p. 604, 1925.

[11] Fairbanks, H. W., U. S. Geol. Survey Geol. Atlas, San Luis Folio (No. 101), 1904.

[12] Davis, E. F., *op. cit.*, p. 408.

derived from diatomoceous earths. No sources of silica appear possible for the Monterey cherts which were not discussed in connection with the Franciscan cherts . . . The latter have here been interpreted as due to siliceous springs associated with the intrusion and extrusion of certain igneous rocks of a peculiar type."

Lawson, in his study of the geology of Carmelo Bay,[13] proposed that the siliceous shale had been derived largely from the alteration of volcanic ash in sea water. Rubey[14] has favored this hypothesis in his discussion of the siliceous Mowry shale of the Black Hills region, and states that the origin of this shale "is intimately connected with the occurrence of altered volcanic ash * * *." He suggested that the same origin may apply to the California 'Monterey shale.'

English[15] proposed that a siliceous mud which had been derived from a rhyolitic land mass would account for the siliceous shale.

It seems possible, then, that there may be many origins for the siliceous shales, and it is probably as futile to attempt to settle on any one theory for the origin of the entire series as it is to pick one lithologic type to represent the whole formation.

Local Geology.

The areal distribution of the formations exposed in the part of Carmel Valley where building stone is being quarried is shown on the accompanying geologic map,[16] while the stratigraphy is graphically represented in the columnar section which accompanies this map.

The building stones described in this report are not now in the same form as they were when first deposited in their basin. They are the product of various agencies which have operated during the time subsequent to their deposition.

Uplift and folding have produced a certain amount of fracturing and jointing in the strata. The major faults and axes of folding have been indicated on the map. Their detailed study is important in prospecting for they control to some degree the distribution of certain rocks; that is, faulting in some cases makes it impossible to develop certain stones ordinarily of commercial value either because of intensive breaking near the fault plane, or because of completely cutting out of the desired unit. In this area where the sediments lie on a granite basement, they have been profoundly influenced by the structural movements in the basement so that it is difficult to find unfractured areas in the shale. As the distance separating a portion of the sediments from the underlying granite decreases, they follow more closely the structural lines of the basement. An example of this feature is the occurrence of nearly perfect rhomboid blocks near the south end of the area where the regularly jointed ledges are situated within 600 feet, stratigraphically, from the granite (see Figs. 4 and 5). North of this region, as the stratigraphic distance from the basement increases, fracturing in the shale becomes complex and it is difficult to find dominant joint planes.

---

[13] Lawson, A. C., The geology of Carmelo Bay: Univ. Calif. Publ., Bull. Dept. Geol., vol. 1, pp. 24–28, 1893.

[14] Rubey, W. W., Origin of the siliceous Mowry shale of the Black Hills region: U. S. Geol. Survey Prof. Paper 154, pp. 153–170, 1928.

[15] English, W. A., Geology and oil resources of the Puente Hills region, southern California: U. S. Geol. Survey Bull. 768, pp. 31–33, 1926.

[16] The distribution of some of the post-Monterey gravels and sands has been taken from the following report: Beal, Carl, The geology of the Monterey quadrangle, California, unpublished A. M. thesis, Dept. of Geology, Stanford University, 1915.

In the intensity of the uplift of the strata, dips of 20° to 45° have been produced in the rocks. This feature has often proved to be of considerable economic significance. If the beds lie in their original attitude or dip only slightly, they may be covered with a considerable amount of overburden. On the other hand, if the beds have been tilted to an extremely steep position so as to stand nearly vertically, the condition may not be favorable for quarrying. Attention should, therefore, be given to this question when prospecting; for the economic development of the stone is determined, among other features, by the amount of waste.

Solution and redeposition of silica in different portions of the sediments have not only cemented the materials more firmly, but have also formed different varieties of indurated stone characterized often by the presence of chalcedony, a variety of silica less hydrous than opal. The brittle, chalcedonized rocks, such as occur immediately below the upper diatomite shown in the columnar section, are generally of no commercial value and it is only those strata which show little secondary alteration that furnish the most uniform, homogeneous architectural stones.

Staining has taken place, in most cases, subsequent to the formation of joint or fracture planes. This is evidenced particularly in the split blocks, such as shown in Fig. 16. The coloration is due in all cases to hydrated ferric oxide which has been formed from the oxidation of pyrite and spread through the rock by permeating ground-water solutions.

PHYSICAL PROPERTIES OF COMMERCIAL STONES

Introduction.

Of the physical tests of building stones, those most essential are for the purpose of determining composition and structure, density, durability, and strength. Of the individual tests, specific gravity, porosity and ratio of absorption, freezing, and abrasive resistance seem to be most indicative for classifying the stones discussed in this report. Texture, color, and compression strength are equally or more important to the architect and have some relation to the other physical properties, but are not as useful in defining primary or fundamental types. Textural and color varieties within a grade are thus quite flexible and are classified, to a large extent, by individual taste.

The physical tests have been made according to standard methods [17]. Specific gravity, porosity, ratio of absorption, and heat and frost resistance have been determined on cubical samples with dimensions of approximately one inch on a side. Compression tests have been determined on two-inch cubes in the laboratory of the Engineering Department of Stanford University. The qualitative data relative to hardness, abrasive resistance, cleavage, and general working properties represent the ideas expressed by quarrymen, stone cutters, and users of the stone.

Location and Detailed Stratigraphy of the Quarries.

Samples from which the data have been obtained were collected from the upper and lower quarries of the Santa Lucia Quarries, Ltd.,

[17] See Ries, Heinrich, Building stones and clay products, New York, 1912.

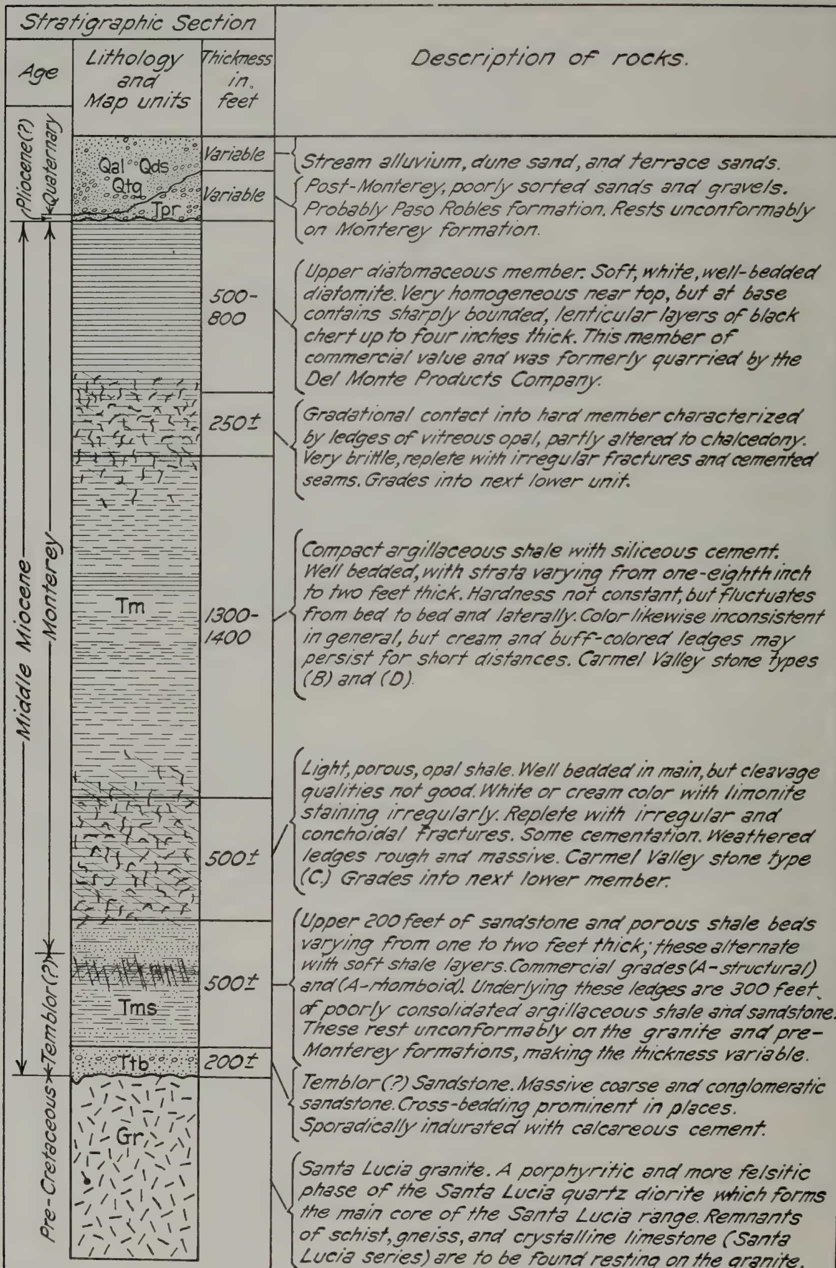


FIG. 3. The symbols indicating the various geological formations are used on the accompanying geologic map, Plate II. This columnar section shows sequence in deposition. The lower beds are the older.

CALIFORNIA STATE DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST.

PLATE II

GEOLOGIC BRANCH
OLAF P. JENKINS, CHIEF GEOLOGIST.

the 'Sierra Quarry' of H. E. Rogers, and the quarry of Arthur Anthony. For the location of the quarries, the accompanying geologic map should be consulted. The descriptive geologic section which follows, give the location of the samples in respect to the stratigraphic column of the sedimentary beds of each quarry. In figures 23 and 24,

Fig. 4. Portion of upper quarry of Santa Lucia Quarries, Ltd., located on south slope of Hill 1076 (see map). Shows contact of strata graded as 'C' material overlying those of dominantly 'A' grade. Major cutting follows the dip of the 'A-rhomboid' ledge. Beds here dip approximately 25° northeast.

Fig. 5. Detail of specimen of 'A-rhomboid' and the producing ledge at the upper quarry of the Santa Lucia Quarries, Ltd. The block is approximately 2 feet high.

certain physical properties and the classification of the samples are graphically shown.

At the upper quarry of Santa Lucia Quarries, Ltd., shown in Plate II and Figs. 4 and 5, the beds strike N. 65° W., and dip 25°

northeast. Beginning at the top of the series with the contact of the type 'C' grade as shown in Figs. 4 and 5, the section is described as follows:

		Thickness in feet
Unit 1.	Buff to cream porous tough massive diatomaceous sediment which grades laterally and vertically into white porcellaneous bands. Broken by strips of paper-thin well-bedded shale. Type 'C' material. Samples of SL-1 (*a, b, c, d, e, f*). (See Fig. 23) Greater than	20
Unit 2.	Soft 'C'-like material, but softer than type 'C' and of no commercial value at present	20
Unit 3.	Gray shaly sandstone beds averaging 1 foot in thickness. Type 'A-structural.' Sample SL-2	2–4
Unit 4.	Soft argillaceous shale, well-bedded. A poor type 'C'	20
Unit 5.	Massive shaly sandstone with siliceous cement. Much like unit 3, but with slightly darker color. An 'A-structural' stone. Sample SL-3. (See Fig. 18)	3–5
Unit 6.	Soft punky white to cream pulverulent shale, like unit 2. Waste rock	10
Unit 7.	Porous buff to dark sienna massive ledge-forming shaly sandstone. Porosity due to solution of calcareous organisms. Beds 1 to 3 feet thick. A subtype of type 'A' having the trade name 'Imprisoned Sunlight'	15
Unit 8.	Soft gray clayey sandstone, easily weathers forming deep soil. Waste	25
Unit 9.	Hard gray sandstone ledges, each 1 to 3 feet thick. Type 'A-structural stone'	15
Unit 10.	Soft sandy shale. Waste	10
Unit 11.	Well-defined bed of sandy shale indurated with opaline cement. Dominant joint planes with strikes of N. 12° W. and N. 80° W., both dipping 75° S. Type 'A-rhomboid.' Samples SL-5 (*a* and *b*). (See Figs. 5 and 19)	4
Unit 12.	Soft shale covered with deep soil	30
Unit 13.	Lower ledge of 'A-rhomboid' stone, well jointed and resembles unit 11 in all respects	4
Unit 14.	Soft shale and sandstone with deep soil covering. Waste. This unit rests with irregular contact on the underlying Santa Lucia quartz diorite, generally known as granite	100+

FIG. 6. Lower quarry of Santa Lucia Quarries, Ltd. This quarry furnishes the 'B' and 'D' grades of Santa Lucia Stone. Strata dip gently northeast.

The above section applies particularly to the openings made on the south slope of hill 1076 and holds, in a general way, for the length of the upper quarry indicated by the black line on the map, Plate II. The sediments are representative of those deposited in shallow water

and are to be found where the formation outcrops in proximity to the old granitic land mass as in the southern end of the area mapped.

At the lower quarry of Santa Lucia Quarries, Ltd., the strata are well exposed (see Fig. 6), but the stratigraphic assignment of the two types of stone produced there, 'B' or patio (Sample SL-6, shown in Fig. 20) and 'D' or building (Samples SL-7 and SL-8) is difficult, for they pass into one another laterally and vertically and are separated chiefly on the basis of hardness, abrasive resistance, and dimensions. In general, however, the harder or 'B' material comes from the uppermost layers exposed at the opening.

The strata yielding commercial stone at the quarry of Arthur Anthony are shown in Fig. 7. The picture does not show the complete extent of the producing beds which strike N. 65° W. and 30° S. Jointing in the quarry is fairly consistent with the major system at N. 5° W. to N. 10° W.

FIG. 7. Quarry of Arthur Anthony. South-dipping beds of commercial stone at (a) and (c) separated by soft, thinly bedded waste-rock (b). Bed (a) is approximately 30 inches thick.

		Thickness in feet
Unit 1.	Massive bed of brown to mauve petroliferous siliceous shale. The dark color is due to a petroleum-like residue which is removable by ignition and slowly disappears during weathering. Well-developed subconchoidal cleavage. Many small shells (*Foraminifera*) have been replaced by pyrite which remains unoxidized for a time in fresh exposures. Samples A-1, A-2, and A-4. (See Figs. 21 and 24.) Used as either patio or wall rock	3
Unit 2.	Thinly-bedded soft porous diatomaceous shale, beds 1 to 3 inches thick. Waste	6
Unit 3.	Massive bed, like unit 1 in all respects. Sample A-3. Size determines whether the stone is used for patio or building	3

Samples A-6 (a) and A-6 (b) were taken from stone which had weathered one year. This was done for the purpose of comparing freshly quarried rock to the weathered stone (see Fig. 24).

		Thickness in feet
Unit 1.	Light buff or yellow dense shale possessing fairly even cleavage. White surface layers form on outer surfaces of blocks when weathered. Graded as building stone. Samples R-1 and R-6	10
Unit 2.	Dense light-buff and cream-colored shale with conchoidal or subconchoidal fracture. Good wall rock. Sample R-2	4
Unit 3.	Hard, dense, massive bed of cream-colored siliceous shale, concentrically stained with brown iron hydroxide streaks. Fairly even cleavage giving large flat surfaces. This material is hard enough to serve as patio or flagstone. Some of the large stained blocks are shown in Fig. 9. Sample R-3	7

In addition, mention should be made of sample R-7 from a small outcrop below Rogers' main quarry. This rock, sold under the name of 'blue rock', is very hard, has a high density, and is a good structural stone. Unfortunately, the bed producing this type of rock has been cut out by the fault shown in the vicinity of the quarry and consequently has only a small lateral extent.

Production at H. E. Rogers' 'Sierra Quarry' is at present limited to approximately 20 feet of strata which strike N. 50° W. and dip 20° S. and have a small overburden of Quaternary river gravels. The quarry is shown in Fig. 8. The producing beds may be divided into the following series:

Fig. 8. 'Sierra Quarry' of Mr. H. E. Rogers. South-dipping beds of commercial stone (Tm) overlain by Quaternary River gravels (Qtg) which were deposited at a time when the Carmel River occupied a higher level.

Classification of the Stone.

Before giving the physical properties of the types of stone, it is well to correlate the various trade names in use which apply to these types and to adopt a nomenclature for this report. The following chart shows the names given the different classes at the Santa Lucia Quarries, Ltd., the 'Sierra Quarry' of H. E. Rogers, and the Carmel Stone Quarries, owned by Arthur Anthony. The nomenclature of types adopted for use in this report is essentially that used by the

Santa Lucia Quarries, Ltd., since it is all inclusive and attempts a rational classification:

Santa Lucia Quarries	*Sierra Quarry*	*Carmel Stone Quarries*	*Types of Carmel Valley Stone described in this report*
'Santa Lucia Stone' or 'A' type			Carmel Valley 'A-rhomboid' and Carmel Valley 'A-structural.' Structural, patio, and flagstone.
'Carmel Stone' or 'B' type	Patio stone, flagstone, or building blocks	Patio or building stone, depending on size of blocks	Carmel Valley type 'B.' Structural or patio stones.
'Monterey Stone' or 'C' type			Carmel Valley type 'C.' Light structural stone.
Soft 'Carmel Stone' or 'D' type	Building stone and garden wall rock, but *not* for patio use		Carmel Valley type 'D.' Soft building stone or wall rock, but *not* for patio use.

It will be noticed that certain types are not found at certain quarries. As emphasized before, these different rock types characteristic of certain areas are controlled by the location of former shore lines of the basin of deposition and can be found only in these particular areas. Areal mapping is the most satisfactory method of procedure in prospecting in order to yield information concerning the extent and variation of the various major types.

The arrangement of the following classes of stone in alphabetical order is not dependent on the progressive increase or decrease of some one physical property, nor is it based on the preference for one type over another for all uses. The classification represents arbitrary designations for the purpose of judging the various kinds of commercial stone.

Type 'A'

Two main types of 'A' stone are included here, 'A-structural' and 'A-rhomboid.' Although these two stones should probably have entirely different alphabetical indices, they are grouped here with the names 'structural' and 'rhomboid' to conform with the names already given by the quarrymen producing the stone. The geologic occurrence and lithologic similarities of the stones also suggest grouping them in this manner.

'A-Structural.'

A siliceous gray sediment containing a high percentage of sand, but having sufficient silt and clay to give it a smooth texture is classified as 'A-structural.' Fig. 18 shows the stone in thin section, while Fig. 10 shows a use of a subgrade of the natural stone, 'A-lichen.' This subgrade title has no further value than as an indication of the organisms which grow on the surface in the natural outcrop and which may not continue to live if placed in a different environment.

Porosity of the 'A-structural' stone averages 38 per cent. This porosity is due to the leaching of small calcareous shells (*Foraminifera*) from the rock by percolating ground water as well as to the primary porous condition of the original, unaltered sediment. In this respect it differs from the stone called 'Imprisoned Sunlight' in that the latter is slightly darker in color and has a higher porosity due to complete

FIG. 9. Detail of patio and flagstone at the H. E. Rogers 'Sierra Quarry,' showing cleavage surfaces of the stone and concentric staining due to the presence of iron hydroxide. The length of the notebook shown is 7½ inches.

leaching of the shells. However, these two varieties come from different beds and are easily graded. Ratio of absorption and specific gravity[18] are also shown in Fig. 24.

The homogeneity of the 'A-structural' type is indicated by the compression tests on dry 2-inch cubes which give 7700 pounds per

[18] Weight per cubic foot may be obtained by multiplying the given specific gravity by 62.5.

square inch perpendicular to the bedding and 7000 pounds per square inch parallel to the bedding. The absence of shale partings and the massive character of the bedding give to the stone a uniform fabric throughout.

Freezing tests have been carried to 123 times without any recognizable change in the structure of the samples.

This is an excellent architectural stone for wall rock, such as shown in Fig. 10. The rough finish makes it a particularly attractive stone for informal use, while chisel-dressed stone of this grade with its soft colors should have a rather general application. Although this type of stone withstood the freezing tests well, as far as they were carried, it should be used in such a place as base course with considerable caution. There would be some danger of disintegration on freezing of a stone with such a relatively high ratio of absorption. No recommendation can be made at the present time as to the use of the stone for patio since no data are available concerning such use, and the artificial abrasive tests are of little value in judging a stone that has not been submitted to actual wear.

FIG. 10. Dry wall of massive 'A-lichen,' of subtype of 'A-structural.' (*Photo by courtesy of John Bathen.*)

'A-Rhomboid.'

This stone, a dense sandy shale which contains a small amount of argillaceous matter, is characterized chiefly by its even joint surfaces at angles of 60° to 65° as shown in Fig. 5. Colors vary from gray to buff and brown, the deeper brown occurring along joint faces. Fig. 19 is a photomicrograph of this type of stone in thin section.

Compression tests perpendicular to the bedding show good failure with strength of 8500 pounds per square inch perpendicular to the bedding and 7500 pounds per square inch parallel with the bedding. Such a difference is to be expected due to the perfect cleavage which this type possesses.

Freezing tests were discontinued at the 146th time and up to that point the samples showed no disintegration.

The low porosity and ratio of absorption make this stone one of the most resistant to freezing of all the grades. It is to be recommended for use in base courses, walls, and other places where it is exposed, as well as patio, flagstone, and steps as illustrated in Fig. 17.

In the chart showing the physical properties of the grades, Santa Lucia 'A' has been included under the large grade type 'B,' for the reason that they may both be used for the same purpose. That is, physical properties alone can not be the deciding factor in differentiating the uses of the two grades. But the textural differences and the architectural uses of the two types of stone are sufficiently marked to warrant the separate designation of type 'A.'

Type 'B'

This class, of which the major portion of the commercial deposits consist, is the common 'Carmel Stone.' Some quarrymen have given

FIG. 11. Grade 'B' stone used here throughout for both walk and wall. (*Photo by courtesy of John Bathen.*)

the type no alphabetical index, but prefer to call it merely patio, flagstone, or wall, depending on the size of the blocks being quarried.[19]

Coloring varies considerably in this stone from buff to brown with marked concentric staining as shown in Fig. 16. Although the 'B' material has the appearance of much of the 'typical' California siliceous shale which is supposed to consist largely of opaline silica, when studied in thin section the 'B' stone is seen to consist largely of minute clay shreds as shown in photomicrographs of Figs. 20 and 21.

The low porosity and ratio of absorption of the 'B' type compare favorably with those of the 'A-rhomboid' material. In fact, the physi-

[19] A patio block is considered to have the cleavage surface at least 100 square inches in size; a flagstone, at least 300 square inches.

cal properties, with the exception of compression strength, are so nearly alike that they are both adaptable to the same use, such as patio, steps, and flagstones. Textural and architectural properties are, however, greatly different.

Freezing tests were carried to 123 times on this stone without evidence of disintegration appearing.

Compression tests on dry 2-inch cubes gave a strength of 4500 pounds per square inch parallel to the bedding and 7700 pounds per square inch perpendicular to the bedding.

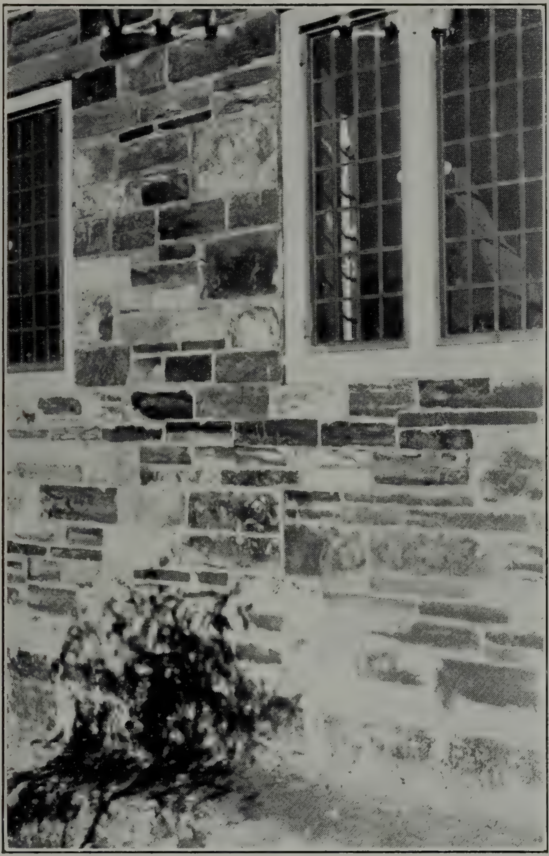


Fig. 12. Detail of 'B' stone of figure 11. Shows use of blocks which have been stained by iron hydroxide along former joint planes. (*Photo by courtesy of John Bathen.*)

Considerable use has been made of this stone in interior work such as that shown in Fig. 16. There advantage of the concentric staining has been taken to produce an interesting effect. However, the type is not limited to interior use and in several cases (Figs. 11, 12, and 13) has served as the principal grade for walls, patios, and steps.

The large blocks for flagstone such as shown in Fig. 9 must be of sufficient hardness and low porosity to prevent spalling when subject

to use. Those samples which have been graded as patio or flagstone (samples SL-5, SL-6, R-3, R-7, and the 'A' numbers), because they are known from practical experience to be hard enough, are seen to have lower average porosity than the 'D' stone which resembles the

FIG 13. Variety of uses of rough-dressed 'B' stone. *(Photo by courtesy of H. E. Rogers.)*

FIG. 14. Exterior use of rough-dressed 'C' grade stone. The rock is laid with bedding in a horizontal position. *(Photo by courtesy of John Bathen.)*

'B' stone very closely (see Fig. 24). Porosity and ratio of absorption are in these cases, then, a rough index of the abrasive character, or wearing quality of the stone.

Type 'C'

In typical development, this stone consists largely of opaline silica, some of which has been derived from diatom shells, cementing angular quartz and feldspar grains as shown in the thin section photomicrograph of Fig. 22. The mineral matter of this type of stone is considerably lower than that of the other types because this type is composed of practically pure opal. The differences in specific gravity of mineral matter of the types is shown in Fig. 23. The terms 'diatomaceous earth' or 'kieselguhr' might be applied to this grade of stone, since it conforms to the definition, 'a light earthy material which from some sources is loose and powdery and from others is more or less firmly coherent.'[20]

FIG. 15. Detail of rough-dressed 'C' of Fig. 14. The walk is of 'B' grade stone. (*Photo by courtesy of John Bathen.*)

The material is characterized by an extremely high porosity which makes its use limited to interior work or to protected exterior jobs such as shown in Fig. 17.

[20] Ricketts, A. H. American mining law. Cal. State Division of Mines, Bull. 98, p. 13, 1931.

FIG. 16. Interior use of 'B' or 'Monterey' stone, matched by symmetrical placement of split blocks, concentrically stained. (*Photo by courtesy of John Bathen.*)

FIG. 17. Exterior use of sawed 'C' stone. The steps are of 'A-rhomboid.' (*Photo by courtesy of John Bathen.*)

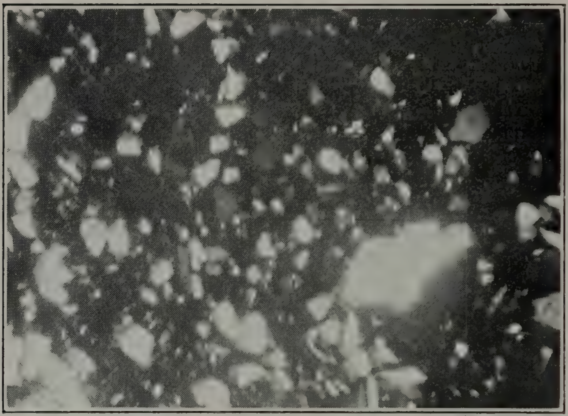


FIG. 18. Photomicrograph of thin section of the siliceous sandstone occurring near the base of the formation and exposed at the upper quarry of Santa Lucia Quarries, Ltd. Sample SL-3. The angular feldspar and quartz appear white against the isotropic, opaline matrix. Magnification x 40; taken in double polarized light. Type 'A-structural' Carmel Valley stone.

FIG. 19. Photomicrograph of thin section of sample SL-5 showing the angular clastic material (feldspar and quartz), which appear white, embedded in the dark, isotropic groundmass. Magnification x 40; taken in double polarized light. Carmel Valley stone, type 'A-rhomboid.'

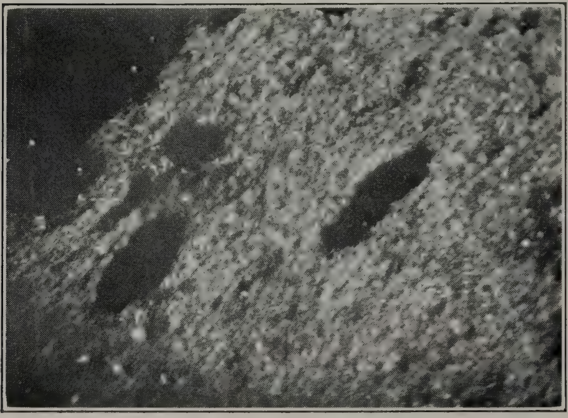


FIG. 20. Photomicrograph of thin section of sample SL-6 showing the trace of bedding plane from upper right to lower left quadrant by parallel arrangement of the clay minerals. The black areas have been deeply stained with hydrous ferric oxide. Magnification x 40; taken in double polarized light. Type 'B' Carmel Valley stone.

The high ratio of absorption and consequent danger from freezing make this stone valueless for base course or exposed wall rock. In the laboratory after eight freezings the samples were completely disintegrated.

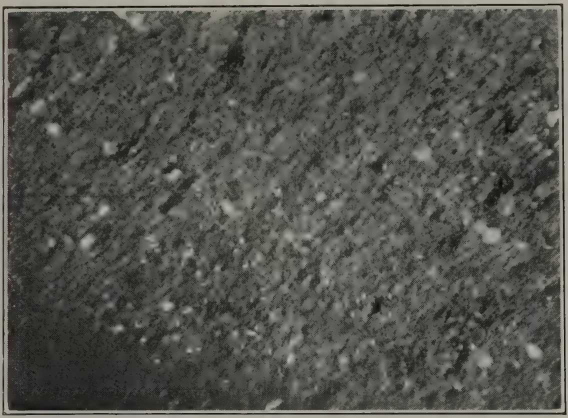


FIG. 21. Photomicrograph of a thin section of sample A-2 cut perpendicular to the bedding which may be traced from the upper right to the lower left quadrant by the parallel arrangement of the clay minerals. A small percentage of angular feldspar and quartz grains are embedded in the clay matrix. Magnification x 40; taken in double polarized light. Type 'B' Carmel Valley stone.

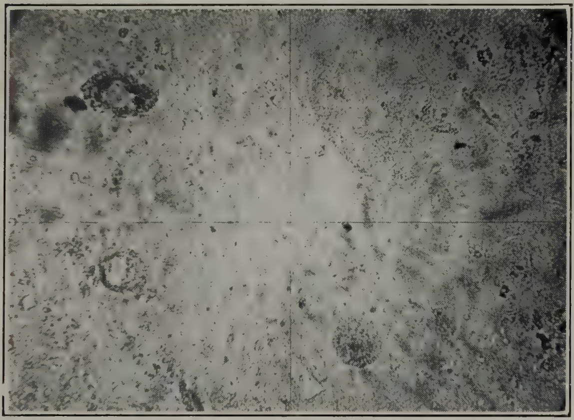


FIG. 22. Photomicrograph of thin section of sample SL-1 showing remnants of organic débris which can still be recognized. In the upper right-hand corner is a fragment of a diatom shell embedded in the opaline matrix. At the lower end of the N-S cross-wire is a small, angular feldspar grain. Magnification x 165; taken in ordinary light. Carmel Valley stone, type 'C.'

Compression tests gave strengths of 4200 pounds per square inch perpendicular to the bedding and 4100 pounds per square inch parallel to the bedding. This homogeneity, which is to be expected from the more or less massive nature of the beds, indicates the uniform fabric of the material, and the soft cream to buff colors, which are likewise

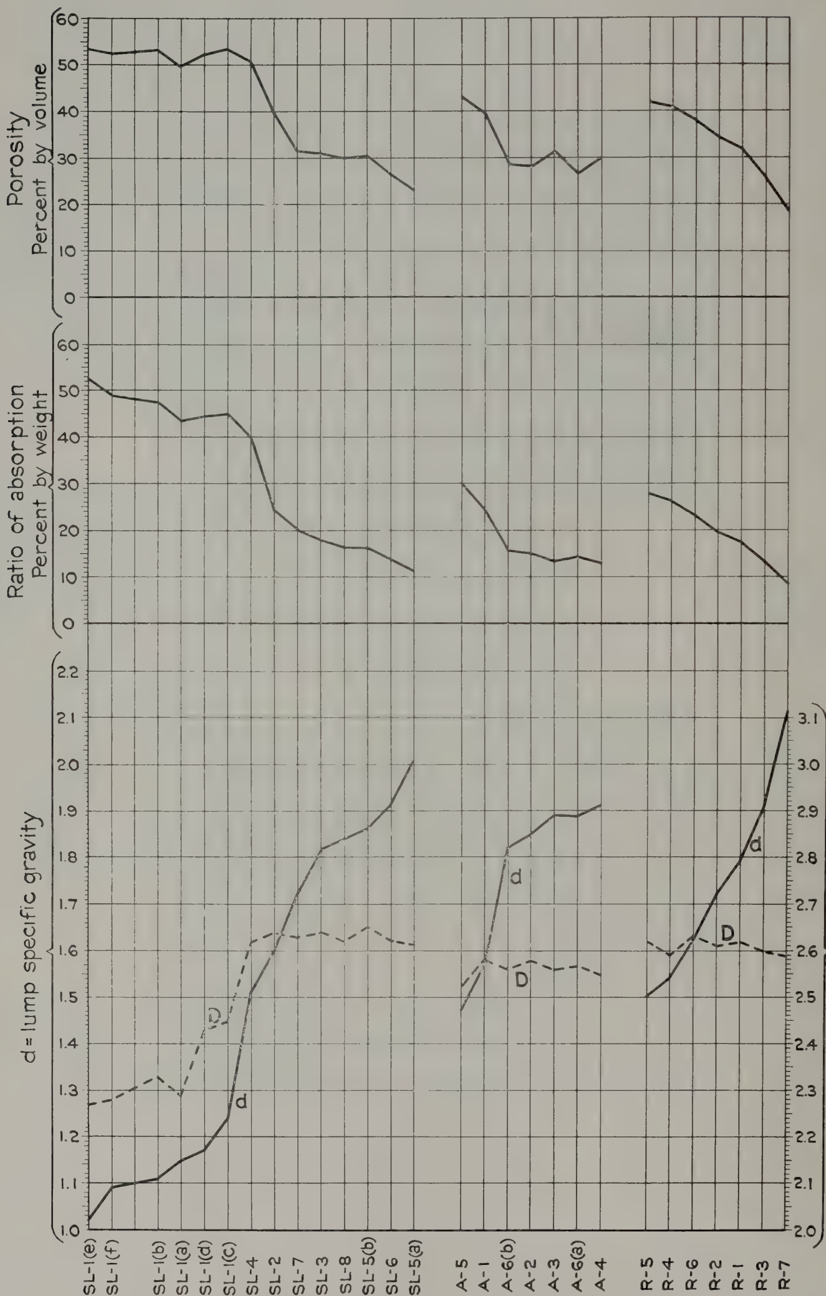


FIG. 23. Diagram showing porosity, absorption, and specific gravity of quarry samples of building stone from Carmel Valley, California.

rather uniformly distributed in the main body of the stone, make it particularly adaptable for sawed tiling. This use, which is not yet developed to any extent, deserves more attention in the future.

Type 'D'

This type which is similar to type 'B' in lithology is considerably softer than the latter and is limited to those uses where not exposed to abrasion of any sort. Compression strength of 4200 pounds per square inch parallel to the bedding and 7500 pounds per square inch perpendicular to it, show that the rock is a good stone structurally, but the somewhat high ratio of absorption prohibits its use in base courses and similar jobs where there is danger of soaking and freezing. Laboratory freezing tests disintegrated the samples at the 30th time.

Tile, sawed from this grade, would give a denser material than that made from type 'C' stone. Moreover, the staining of the 'D' rock, buff to brown in general, should give a tiling which may be used in jobs where the lighter colored 'C' material is undesirable.

Concluding Remarks.

There are certain general features which characterize the stones quarried from the Monterey formation which should be mentioned when contrasting them with some of the other architectural stones.

In general, they are comparatively light. The specific gravity of the major part of the stone averages 1.8. This is equivalent to a weight of approximately 113 pounds per cubic foot. Thus, the comparatively light shipping weight should aid in the commercial development of the stone.

The good bedding and well-developed joint faces which characterize certain grades and make them easy to work and shape, emphasize their adaptability for fine veneer work. The more massive beds which are consequently quite homogeneous in structure are particularly good for relief or bas-relief carving.

There is a considerable range of colors which are naturally blended and the deposits are so extensive that many varied color-tones may be easily matched.

The only precautions which might be suggested, relate to the use of the softer varieties of the shale in those places where there is danger of considerable abrasive action. The integrity of quarrymen, architects, and builders must be relied upon to assure that softer grades of the rock are not placed where experience has shown these grades to be inferior to others.

Moreover, when specifying any grade of material, proper consideration of the physical properties of the stone should be made, especially when there is a possibility that it is to be used in locations exposed to weathering or to treatment to which it had not heretofore been subjected.

As a record of the enduring qualities of the stone, Carmel Mission, built in 1773–79, stands as a beautiful memorial. Several types of

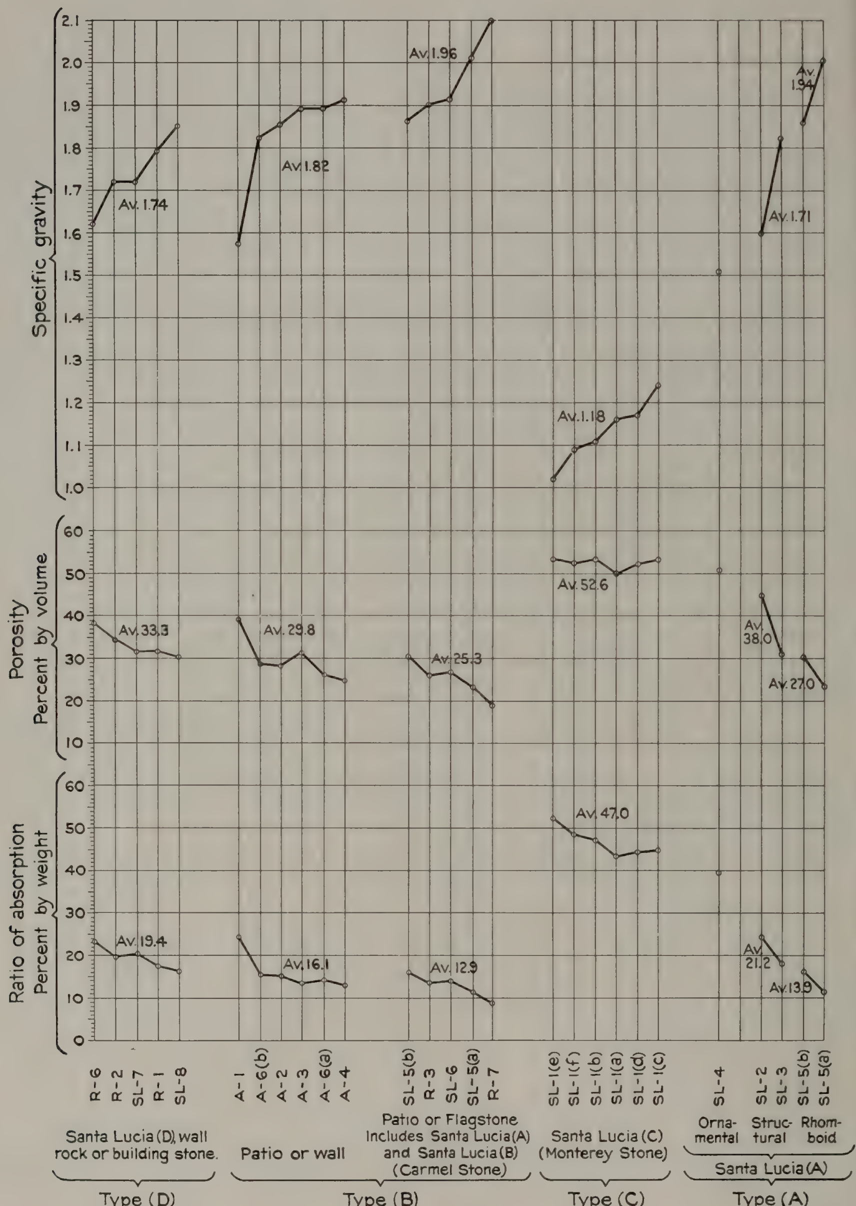


FIG. 24. Diagram showing porosity, absorption, and specific gravity of various types of building stone from Carmel Valley, California. Each point represents the average of three determinations.

Carmel Valley stone were used in its construction. A portion of the Mission is shown in Fig. 25.

Samples of the various types of stone described have been placed in the museum of the State Division of Mines, Ferry Building, San Francisco, and may be consulted by anyone who is interested in standardizing the architectural stones wherever they are being commercially developed.

FIG. 25. A portion of Carmel Mission, built in 1773–79, in which Carmel Valley stone type 'A' was used in the construction of steps. (*Photo by courtesy of John Bathen.*)

SEDIMENTS OF MONTEREY BAY, CALIFORNIA

By E. Wayne Galliher

OUTLINE OF REPORT

ABSTRACT

The object of this study is to give data concerning the distribution, the physical and chemical properties, and the factors controlling the formation of the sediments of Monterey Bay, California. The data have their most important use in the interpretation of the origin and history of sedimentary rocks.

Both the subaerial and submarine sediments have a fairly orderly distribution which is controlled by physical factors. These factors are wind forces, wave action, marine currents, and the configuration of the surface upon which the sediments rest.

The original sediments in places are modified chemically, to form black mud through the agency of bacteria which may also play a rôle in the formation of oil. The carbonate content of the sediments is controlled largely by their proximity to rock bottom, jutting points and gravel areas. It is probable that the distribution of phosphates in sediments depends upon the nature of the basin of deposition; that is, whether it is open and allowing good circulation to the water, or closed and governed by special hydrologic conditions.

As a contribution to the knowledge of the formation of sediments, these data may be used in geological study of stratified rocks. Hence, the oil geologist may apply this work directly to his problems of stratigraphic correlation; the producer of certain non-metallic materials, such as sand, gravel, and building-stone, may more intelligently prospect for and develop those resources.

Certain of the deposits described here are of commercial importance. Sand deposits of potential economic value border over one-half the present shore-line of Monterey Bay. There are different grades of sand with correspondingly different uses. The principles controlling the distribution of the various grades discussed in the report may be applied in exploration and development elsewhere.

In addition to the geological applications, there are phases of the study which may be applied to economic biology. The nature of the marine bottom exerts a profound influence on the distribution of organisms. The accompanying chart which shows, in addition to the distribution of sediments, the location of fishing grounds, should be of considerable value to commercial fishermen.

INTRODUCTION

Location of the Area.

Monterey Bay provides an interesting area for a study in oceanography, not only because it lies along a coast with considerable surface relief, but also because it is marked by the presence of one of the best developed submarine valleys of the North American Pacific slope. The bay is located between latitudes 36° 35′ N. and 37° 00′ N. and longitude 121° 45′ W. and 122° 00′ W., Greenwich meridian, and embraces an area of some 116 square miles (see Fig. 1).

Both topographic and bathymetric features have a great influence on the formation and distribution of the deposits on the bottom of the bay. A study of these deposits affords a means of comparing them with deposits described from other environments, particularly marine,

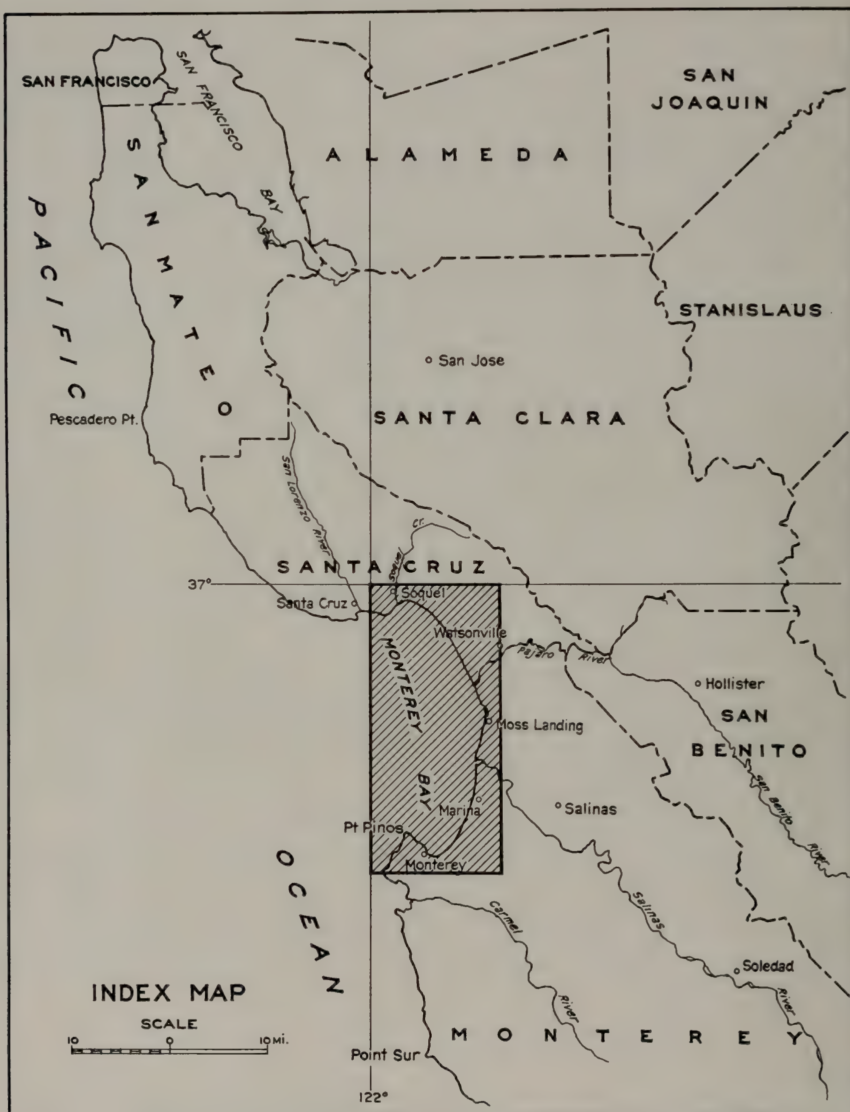


FIG. 1. Index map of a portion of California, showing the location of the area mapped in detail on the lithologic chart, Plate III.

which differ from one another not only as regards physiography, but also as regards the physics, chemistry, and biology of the waters contained in those basins.

Object of the Report.

The present report on sediments in Monterey Bay is the outcome of one phase of a hydrobiological survey begun by the Hopkins Marine Station, Pacific Grove, California, in 1928 under the direction of Professor Tage Skogsberg. The survey involves a study of the hydrology of Monterey Bay, the chemical properties of the water, its biology especially in so far as the plankton (the floating organisms) is concerned, and the bathymetry (submarine topography) and geology of the floor of the basin; it is, in short, an oceanological survey.

The purpose of this report is to present the coordinated data pertaining to the bottom deposits of a single basin and its immediate surroundings, and to compare these data with those of other marine environments. It is believed that the information is of considerable interest to both the biologist and the geologist. The type of bottom,

FIG. 2. Shell deposit on the lee-side of Mussel Point (station No. 51). The broken shells have accumulated on the eroded granite-porphyry. This type of calcareous deposit is characteristic of many of the wave-swept points of the Monterey Peninsula shore-line.

especially the texture of clastic deposits, and the distribution of organisms have been found to bear an important and direct relationship. It is especially intended that the geologist (particularly the oil geologist) will find in this report much information which will prove valuable in the interpretation of the origin of the ancient sediments and of the distribution of the old land surfaces at the time of deposition of the sediments.

Particular attention is given to the distribution of the different kinds of sediments, their relation to source, their mode of transportation, especially in so far as it relates to the hydrokinetics of the immediate basin, and certain phases of their chemistry and biology.

It is not claimed that all the data—and especially those concerned with lithologic distribution—pertaining to this basin are applicable to other areas, but certain features of the study have a broad

application. Only by comparing these data with those from other provinces, can principles of even a semi-quantitative nature be disclosed.

Acknowledgments.

The California Division of Fish and Game placed at the writer's disposal the patrol launch 'Albacore' for all the dredging which was done in the course of the study. To the captain of the 'Albacore', Mr. Lars Wesseth, and to the engineer, Mr. Errol Greenleaf, the writer is deeply indebted for their generous co-operation.

Fig. 3. View southward along the western shore of the Monterey Peninsula from station No. 70. In the foreground and middle distance a thin covering of wind-blown arkose rests on the terrace which is cut in granite.

Thanks are due Professor Tage Skogsberg, not only for aid in starting the project, but for the stimulating interest which he has maintained throughout the course of the work.

Certain suggestions made by Professor C. B. van Neil pertaining to the sulfur cycle and the sulfur bacteria have been very helpful in this study.

The writer is indebted to the late Mr. Roy Paine, Hopkins Marine Station, for the construction of the clam-shell dredge which was used to obtain a large number of the bottom samples.

To many other friends, and especially to Mr. J. B. Phillips, Hopkins Marine Station, the writer is indebted for various courtesies and suggestions.

Literature Relating to Monterey Bay.

The first attention given to the bottom deposits of Monterey Bay was that by Delesse, 1871, in his lithologic chart of the seas of North America [1]. An isolated area of mud surrounded by sand is shown

[1] Delesse, A. Lithologie du fond des mers. Paris, 1871. Chart number 3.

within the limits of Monterey Bay as previously defined. A fairly accurate picture of existing conditions is thus shown. Delesse modestly admits that he knows only imperfectly the geology of the North American coast as well as the marine deposits of the Pacific Ocean. Nevertheless, he calls attention to the fact that there are differences in distribution and kinds of marine deposits along various shore lines. He also outlines the principal differences in lithology and bathymetry between the west and east coast submarine areas of North America. Such differences have not, however, been recognized by some authors when endeavoring to interpret the ancient marine deposits of one area in the light of data applying to recent deposits of another.

A certain amount of information has been supplied by the dredgings of the 'Albatross' in Monterey Bay [2]. While these data, like those of the United States Coast and Geodetic Survey hydrographic charts, are of some use in plotting rock ledges and gravel bars, they are of little value in mapping other types of bottom deposits such as sand, silt, and clay; for different workers designate the same deposits in radically different ways. Hence, if a map is constructed upon their data, it shows but little consistency in the distribution of lithologic types.

FIG. 4. View northward along the shore of Monterey Bay as seen from station No. 56. The low beach-line of the foreground merges in the distance into a shore-line bordered by cliffs of Quaternary sediments 50 to 100 feet high.

Davidson [3] referred to the bottom deposits of the bay in 1897 with this brief description:

> "The latest soundings with the dredge show boulders under the soft muddy bottom at 480 fathoms off Point Pinos. . . . The characteristic soundings adjacent to this valley (the main submarine valley) are fine soft mud, dark gray, dark yellow, and dark green, as far in as 30 fathoms of water, with occasional cases of fine dark sand, even to 150 fathoms."

[2] Bureau of Fisheries Document No. 604. Dredging and hydrographic records of the U. S. Steamer Albatross for 1904 and 1905, pp. 28–42. Published 1906.

[3] Davidson, George. The submerged valleys of the coast of California, U. S. A., and of Lower California, Mexico. Proc. Cal. Acad. Sci. 3rd ser., Geol., 1, p. 92, 1897.

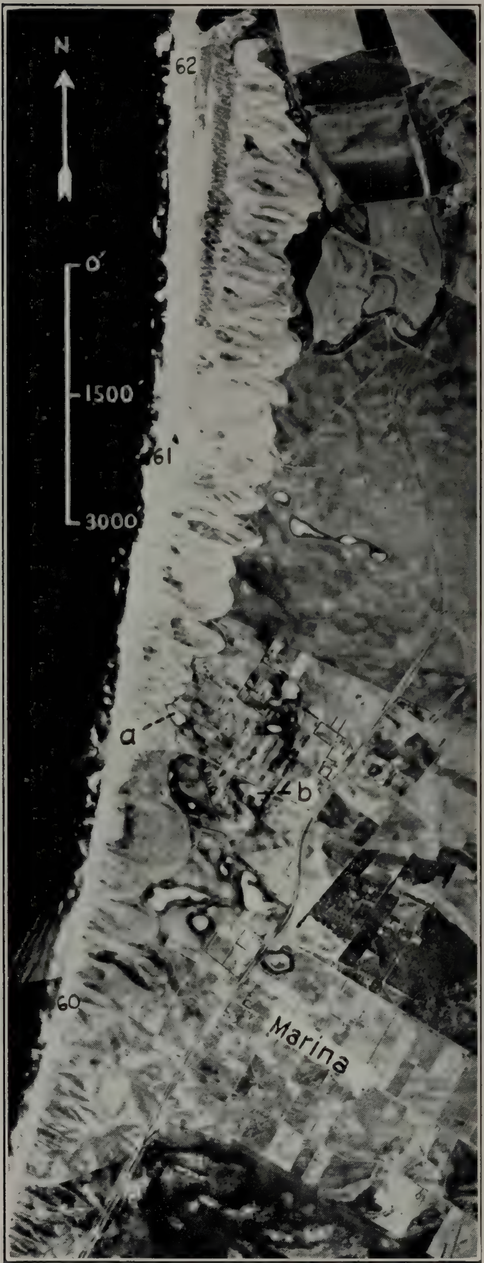


FIG. 5. Aerial photograph of Marina, California, and vicinity. The lobate dunes border the shore of Monterey Bay and have begun to encroach easterly on the saline lakes, many of which are shown. The two lakes marked *a* and *b* have been studied in detail and will be reported on elsewhere. The locations of stations 60, 61, and 62 are also shown. (*Photo by courtesy of the Union Oil Co. of Calif.*)

The first statement is particularly interesting since the deposits in the channel off Point Pinos, which have been dredged during the present survey, are marked by coarse material overlying silt and clay (samples 119, 121, etc., Plate I). Little value can be given to Davidson's record, however, because no definite localities are given.

Data are recorded by Bigelow and Leslie [4] pertaining to hydrology and biology. Their discussion of upwelling and the dynamic state of the water, as well as the suggestions offered by McEwen [5] are of some importance in a discussion of the distribution of the bottom sediments, and will be referred to later.

Bathymetry or Submarine Topography.

Approximately 100 new soundings were made during the course of this survey. These additions to the published chart of Monterey Bay[6] have provided new data in only one locality which effect a material change in the isobaths constructed from information already recorded on the published chart. For the rest of the area, the main bathymetric features, as published, remain the same as before, as shown on the accompanying map (Plate III).

The dominating feature of the submarine topography of Monterey Bay is the channel which divides the area roughly into two halves. Davidson [7] called attention to this feature in 1897 when discussing other submarine valleys of the west coast of North America.

> " . . . at Monterey Bay there is a complete breaking down of the Coast Range for 25 miles, with the mountains receding well inland. Into this broad and deep bight heads the finest of the submerged valleys."

He apparently assumed a subaerial origin for these valleys, judging from the descriptive term employed. Since other possible origins have been entertained, it is probably better to use the noncommital term 'submarine valleys.' Various possible origins are mentioned later.

The main channel trends about N. 70° E. and terminates in the vicinity of Elkhorn Slough where the 100-fathom line comes within two miles of the shore. Cross-sections showing profiles of the channel are included on Plate III. Numerous indentations mark both the northern and southern edges of the main submarine valley, and one large branch with a trend of N. 30° E. forms the chief break in the northern edge. The 100-fathom line of this branch approaches within seven and one-half miles of the northern shore of the bay, and from that point there is apparently a further dividing of the channel in the shallower depths. However, the details of the shallower branches are obscured by the lack of soundings, or by their partial obliteration by sediments which have been deposited in the depressions.

On the accompanying map the maximum depth of the channels referred to above is shown to be 450 fathoms. Larger maps which extend farther off shore show the main submarine channel continuing to at least 2000 fathoms[8].

[4] Bigelow, Henry B., and Maurine Leslie. Reconnaissance of the waters and plankton of Monterey Bay, July, 1928. Bull. Mus. Comp. Zool., 70, pp. 430–581, 1930.

[5] McEwen, G. F. The distribution of ocean temperatures, etc. Int. Rev. Ges. Hydrobiol. Hydroger., 5, pp. 243–286, 1912.

[6] U. S. Coast and Geodetic Survey Chart No. 5403.

[7] Davidson, George, *op. cit.*, p. 75.

[8] Fault map of the State of California compiled from data assembled by the Seismological Society of America, 1922.

Near the southern bight of the bay lies another small channel. It heads near Humpback Rock and has a general course of N. 30° W., but can not be definitely followed in a northerly direction for more than five miles. It differs from the channel which lies north of the main valley in at least two respects: At present, it has no traceable continuous connection with the main channel. Its best development lies within the 50-fathom line, whereas the northern channel is developed more clearly at depths greater than that amount.

The soundings along the southern channel to date have served as the basis for the rather peculiar isobathic construction shown on the map. It is at present impossible to say definitely whether the submarine topography in this particular locality is due to scouring-out or filling-in of material, or both. The answer to this problem will probably remain uncertain until more data relating to currents in the bay have been gathered. That is, it is not suggested that this particular channel has a different origin from the others. They probably all have had the same general history up to a certain time. But the factors which have given the sea floor its present contour between the two fishing grounds, known as the Italian and Portuguese ledges, are not especially apparent.

Outside of these channels there is nothing particularly striking about the bottom of the bay. Humpback Rock, the area of submarine Monterey shale lying immediately east of Monterey, and the submarine slope off the west coast of the Monterey Peninsula may best be described as fairly-even rock floors.

The granite area west of the Monterey Peninsula is probably more irregular than the submarine contours indicate, judging from exposures of the same formation along the shore line, as shown in Fig. 2. Fig. 3 is also a view of the exposed surface. It is apparently quite even, but has been made so by a covering of wind-blown sand. However, dunes in the background of the picture, although they may range to thirty feet high, often have granite knobs and shoulders protruding through them. Such irregularities probably occur below sea level as well as above.

The smooth, sandy, cuspate beach of the eastern shore of the bay from Monterey to Soquel Point (see Figs. 4 and 5) is unbroken except for major tributaries, together with Elkhorn Slough which has been shown by MacGinitie to be a true salt-water estuary [9]. The main tributary, Salinas River, is kept from free entrance to the bay during the major portion of the year by a sand bar; however, in winter during the time of high water the bar is usually washed out.

The dunes along the shore south of Elkhorn Slough form an important topographic feature. They act as a barrier between the large, open, marine basin and small enclosed basins. Some of the enclosed basins hold brackish water, such as the lakes near Seaside and Del Monte, but some are true saline lakes as, for instance, those near Marina (see Fig. 5). A discussion of the latter, which have biological affinities to desert lakes and thus constitute here a special environment, is reserved for publication elsewhere. The little enclosed

[9] MacGinitie, George Eber. Ecological aspects of Elkhorn Slough. Unpublished A. M. Thesis, Dept. Zool., Stanford Univ., p. 12, 1927.

basins deserve mention here, however, in order to call attention to the varied conditions of sedimentary deposition which may be obtained within short distances.

GEOLOGIC SKETCH

Geology of the Immediate Environs.

The geology of the region contiguous to Monterey Bay is fairly complex. Both igneous and sedimentary rocks are exposed along the shore-line, while within the hydrographic basin draining into the bay, metamorphic rocks are also exposed.

Forming the core of Monterey Peninsula, is a granite porphyry, a local phase of the Santa Lucia quartz-diorite. It is the most northerly occurrence of the batholith of the Santa Lucia Range and in the area mapped is exposed continuously along the shore from Point Cypress to the town of Monterey. Numerous pegmatite dikes cut the mass (see Fig. 2). The age of this formation is pre-Franciscan; the Franciscan, in turn, is pre-Cretaceous.

Dredgings indicate that the granite extends west of the Monterey Peninsula at least as far as the 122d meridian and northwesterly to about latitude 36° 40′ where it is covered with sediments. Apparently only boulders, shells, and gravel are deposited on the surface or in the eroded joints off the shore of the peninsula where there is unusually strong wave action.

Unconformably overlying the granite porphyry is the Monterey formation of middle Miocene age. The major portion of the formation consists of the so-called siliceous shales, supposedly composed largely of opaline material. This formation abuts the shore-line at no point in the bay, but occurs in shoal water in the south end of Monterey Harbor immediately off shore northwesterly from the town of Seaside.

To the north of Monterey and extending southeasterly up the Salinas Valley at least as far as San Lucas, lies a series of poorly consolidated sandstones and shales of both marine and fresh-water origin. Their constituents have been derived from the older rocks of the Salinas basin. This series is well exposed along the beach south of Elkhorn Slough, and again north of Elkhorn Slough, from about one mile south of Pajaro River to a point two miles north of Port Watsonville.

At the latter locality marine Pliocene deposits are exposed. These continue northward along the beach without break, to Soquel Point and the 122d meridian.

General Geology of the Drainage Basins.

Since the recent sediments of Monterey Bay may be considered to be derived from the rocks of the basins draining into the Bay, it is not amiss to sketch briefly the geology of the area.

Considered broadly, the Salinas Valley is a synclinal structure in Mesozoic and Cenozoic sediments, flanked on both sides by ranges (Santa Lucia, Gabilan, and Mount Diablo ranges) which consist of metamorphic rocks, such as gneiss, schist, marble, and serpentine, together with quartz-diorite, diorite, and other igneous rocks.

The Mesozoic sediments, known as the Franciscan formation, (pre-Cretaceous in age) are composed chiefly of conglomerates, sandstones, shales, metamorphosed eruptives and cherts. These rocks occur along the southwestern slope of the Mount Diablo Range.

The Cenozoic sediments, ranging in age from Eocene (?) to Recent, comprise arkoses, clay-shales, diatomaceous shales, and the conspicuous opaline shales, dominantly of Monterey (middle Miocene) age. The last are mentioned especially because they form a noticeable part of the Monterey Bay sediments. These Cenozoic sediments contain material (chiefly chert) reworked from the Franciscan rocks. Volcanic rocks, probably Miocene, are also exposed in the Salinas drainage basin. Hamlin[10] has described the Salinas Valley in some detail.

The Pajaro and San Benito rivers and their tributaries drain areas which are geologically similar to the Salinas basin. The Franciscan cherts and associated serpentine, together with the Monterey formation, outcrop over the major part of the areas.

An area of igneous and metamorphic rocks, similar to the Santa Lucia series, is exposed north of Soquel and Santa Cruz. San Lorenzo River carries detritus from this region to the northern end of Monterey Bay. This river also passes through areas of Tertiary sediments comprising the Monterey formation, as well as through sandstones and shales of later age.

In brief, plutonic, volcanic, metamorphic, and sedimentary rocks are to be found in the drainage areas contiguous to Monterey Bay. The lithologic characters of some of the formations are so characteristic that they may be used as indicators of source of sediment.

DREDGING EQUIPMENT

Figs. 6 and 7 show the equipment used during this survey to obtain bottom samples. The tube dredge (Fig. 6) is satisfactory for use in soft mud areas which contain enough silt and clay to prevent the sample from being washed from the bottom of the tube as it is brought up.

Although the mass sampler (Fig. 7) gathers fairly undisturbed samples of sediment, it is not used to obtain material for chemical analysis. The tube dredge collects uncontaminated and sealed samples, and all chemical data, with the exception of those for phosphates and carbonate, are based upon material brought up by it.

SEDIMENTS OF THE BAY

Areal Relations.

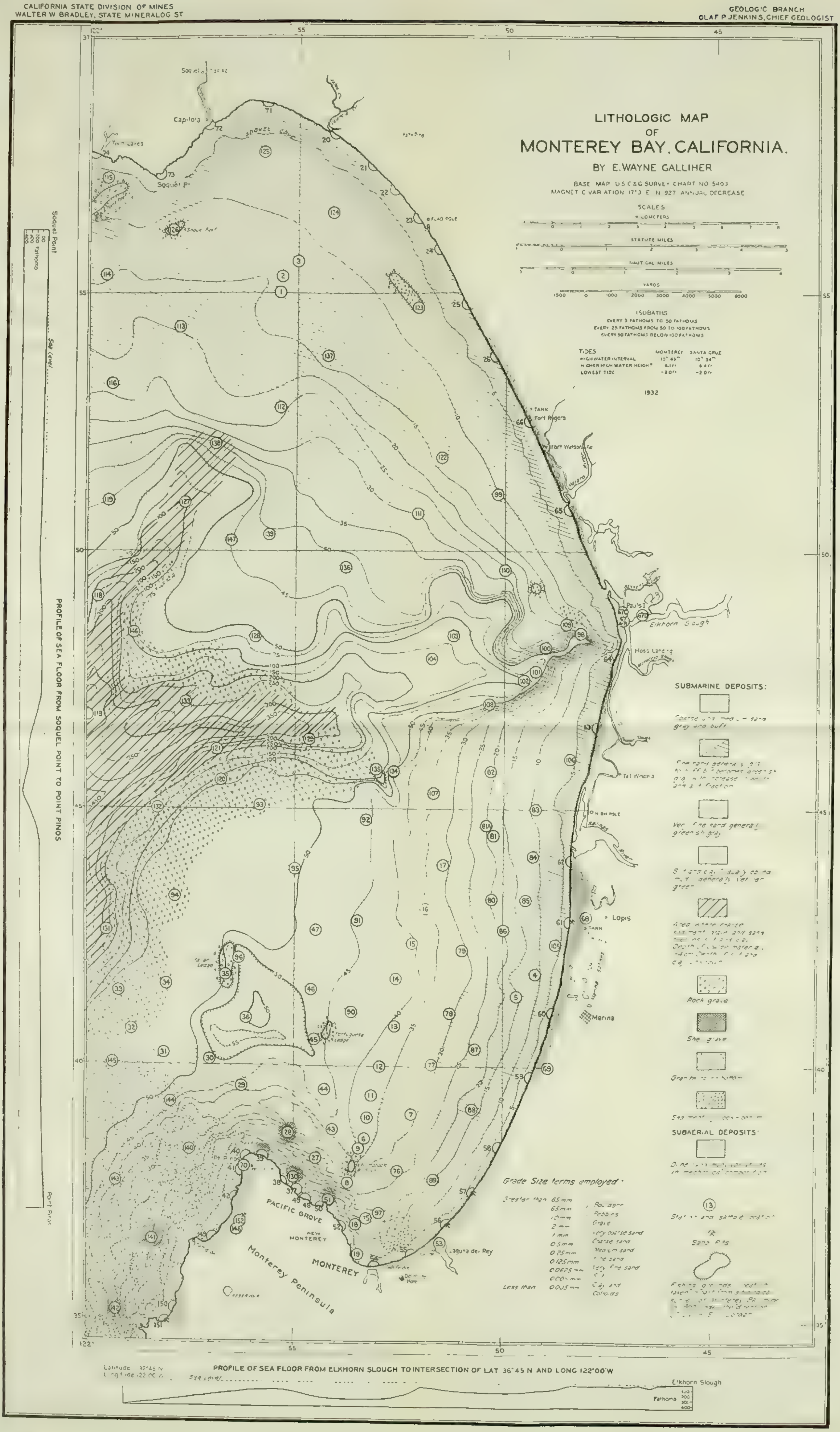
The accompanying lithologic map of Monterey Bay (Plate III) shows the general geology of the submarine bottom and the contiguous shore-line. The distribution of the various classes of loose sediments is based on a large number of mechanical and 'sedimentation' analyses, and on qualitative designations of the samples where they have not been analyzed. The information pertaining to fishing grounds has been obtained from the chart made during the 'Albatross' survey, as

[10] Hamlin, Homer. Water resources of the Salinas Valley, California. U. S. Geol. Survey W. S. Paper 89, 1904.

PLATE III

CALIFORNIA STATE DIVISION OF MINES
WALTER W BRADLEY, STATE MINERALOGIST

GEOLOGIC BRANCH
OLAF P JENKINS, CHIEF GEOLOGIST



noted on the map, from informal discussions with local fishermen, and from dredgings made in the course of this survey. It is hoped that additions to and alterations in the mapping will be made as more information is accumulated.

The major portion of the shore-line of both Monterey Bay and Monterey Peninsula is bordered by wind deposits which have been indicated on the large chart and are shown in Fig. 5. The trend of the dunes along the bay proper is north of west and is particularly easy to follow in the area covered by the aerial photograph. The dunes give indication of the prevailing winds of the region—roughly

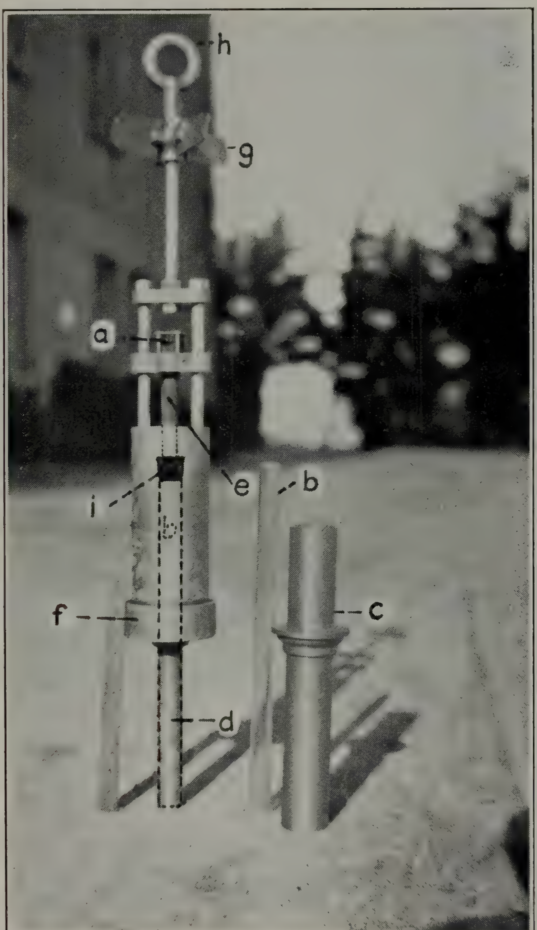


FIG. 6. Assembled tube-dredge used to collect bottom-samples described in this report. The dashed line indicates the position occupied by the glass tube, *b*, in sleeve *d*. The glass tube is connected to the check valve, *a*, with a rubber connecting tube, *e*, which is inserted in the glass tube through rubber stopper, *i*. The brass sleeves, *c* and *d*, are held to the main body of the dredge with the threaded ring, *f*.

northwest. Representative samples of these dunes (numbers 68 and 69, Fig. 11) show good sorting and the occurrence of coarser material on the lee side of the dune than on the windward side. Moreover, the northern sample, number 68, is considerably coarser than the southern, a fact which correlates well with the data presented in later paragraphs concerning the variations in the beach samples. The dunes bordering the western shore of the Monterey Peninsula are not as markedly lobate as those described above. The lobate dunes lie in a relatively open country where the wind has no large topographic

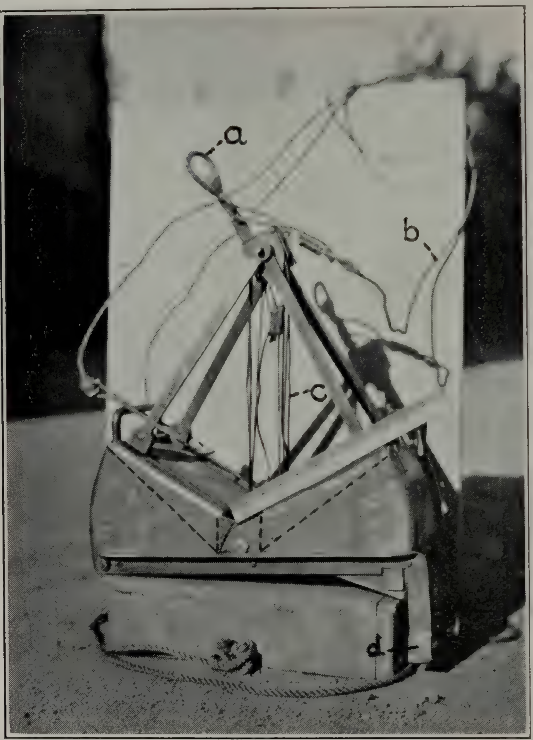


Fig. 7. Clam-shell dredge in open position. The sounding line attaches to turnbuckle, *a*. Both the safety cable, *b*, and the eight-part-line, *c*, attach to the turnbuckle. Impact on the bottom forces the trigger arm, *d*, to release. The dashed line indicates the leaded part of the machine.

barriers to retard its movement. Moreover, the scrubby vegetation characteristic of the area south of Elkhorn Slough in no way hinders the development of the dunes. Quite the opposite feature is true of the wind deposits of the Peninsula. The high hills in the center of the Peninsula serve to deflect the wind and decrease its carrying strength a short distance from the shore-line. This, combined with the interference to dune migration by trees such as live-oak and Monterey pine, hinders the development of perfectly lobate dunes.

Along the southeastern shore of the bay, extending from Elkhorn Slough to Monterey, there is a varied representation of sands. The interesting feature is their tendency to increase in coarseness towards

a certain locality on the beach. Either south or north from the strip of beach between stations 58 and 60 the sand becomes progressively finer. This is shown in Fig. 11 where the samples lying north of sample 60 (e. g., numbers 62, 63, 64) are grouped together and show a progessive shift to the right or small particle size of the graph. Again, samples 54, 55, and 56, lie south of, and are progressively finer than, number 58, as shown in the same figure. Since this area of relatively coarse beach material does not lie opposite the embouchure of any river or stream, such as those areas of coarse shore-sand north of Elkhorn Slough, there is the possibility of another factor controlling the occurrence of the beach sands. The factor is wave action, the direction of which is profoundly influenced by the prevailing wind movement in the region, from north of west to south of east. Less well understood, but probably of minor importance to this particular problem, are tidal currents which operate in this portion of the bay.

In Fig. 8 the wind forces are analyzed vectorially into two components, one parallel to the beach at the point where the wind impinges and one perpendicular thereto. For the purpose here the wave force may be considered parallel to wind force, although quantitative data concerning their divergence or parallelism are not available. Field observations taken during storm show that their parallelism is quite marked. The diagram is largely self-explanatory. It is easily seen that the total effect of the components of force parallel to the beach is to become neutralized at the point indicated by the heavy arrow, which lies within the strip characterized by coarse beach sand. That is, there should be a shifting of sand carried by wave action towards the portion of shore-line where vectors parallel with it become zero. This correlation may be only apparent and is somewhat rough, but will have to remain so until more is known about the hydrodynamics of the region involved. Another fact which is apparently in harmony with the above is the occurrence of relatively coarse sand in sample number 69 from a dune to the east of the coarse beach sand strip; this sand is coarser than that of sample 68 from a dune to the north and east of beach sample 60. The dune sands are derived from the beach material at each locality and are thus a reflection of the different beach sand gradings.

It is possible this shifting was also in progress during a time when the shore-line of the bay occupied a position slightly east of the present one. If so, the conditions found now represent the result of forces acting over a fairly long period of time.

On the lithologic chart the coarse and medium sand has been continued off shore as far as station 76. The mineralogy of this sample indicates that the material is debris derived from the near-by ledge of Monterey shale, and has not been swept from the beach to the north.

So far as has been determined, the material classed as coarse and medium sand is dropped within 0.3 or 0.4 miles of the shore and is carried but a short distance in comparison with the finer grades.

Along the northeastern shore of the Monterey Peninsula there is a progressive increase in coarser constituents of the tide-line deposits towards the west. The analyses of samples 52, 38, and 40 show the increase in the gravel fraction as Point Pinos is approached. At this point the shore-line is subject to the full force of the ocean waves and,

as a consequence, only the coarse sand and gravel can remain while the finer material is carried away.

With increase in depth of water and distance from shore, the sediments become progressively finer. The fine sand unit (e. g., samples

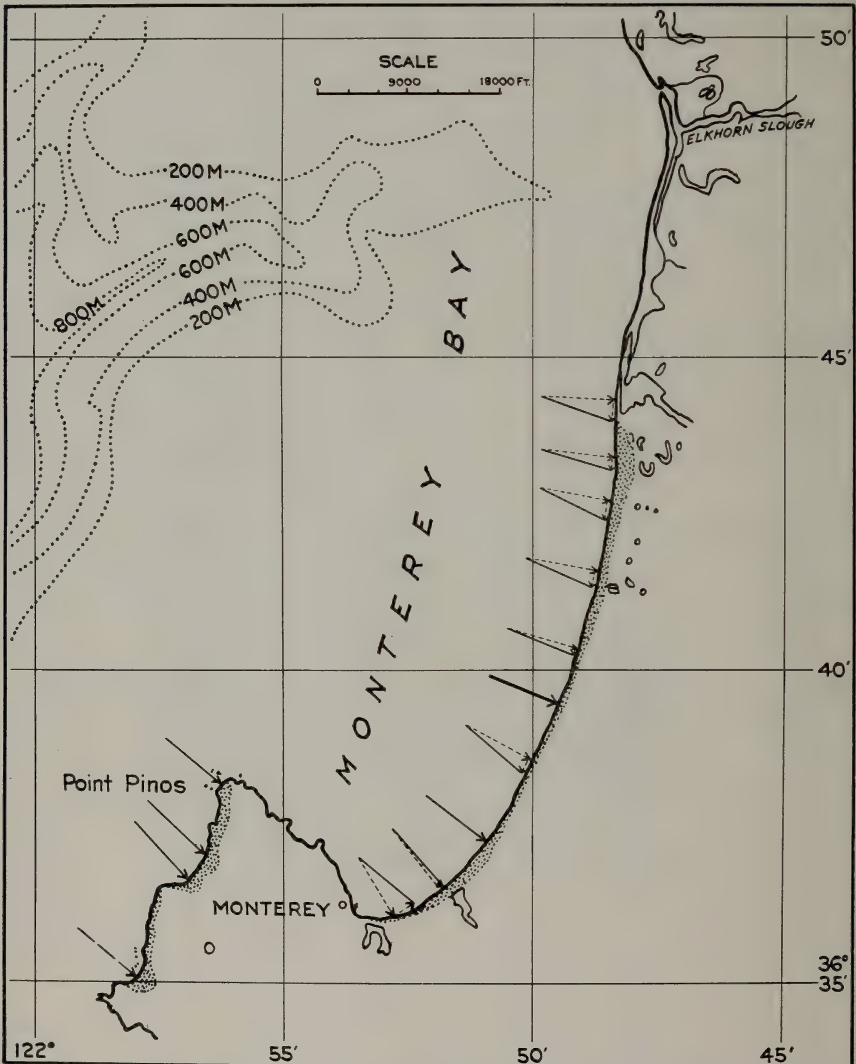


Fig. 8. Chart showing vector analysis of wind force that impinges on the shore of Monterey Bay. The alignment of the dunes, such as those shown in Fig. 5, are used as a rough indication of the direction of the wind force. The wind force indirectly controls the movement of sand along the beach.

26, 27, 87, 88, 105) is marked by a change in color at a depth of approximately 25 fathoms. The change from the ordinary gray or buff sand, which predominates down to that depth, to a grayish green sand is accompanied by an increase in the silt fraction of the sediment. The green color is due to the presence of a ferrous silicate, the origin of which is involved in reactions taking place in the black mud; for

this depth, where silt is being dropped, is evidently sufficiently free of wave movement, allowing the silt to remain quietly on the bottom, or only slightly disturbed, and thus provide an environment in which the anaerobic organisms of the sulfuretum, or black mud environment, can operate. The silt free, clean sediments which occur at lesser depths probably offer no oxygen-free environment necessary for the sulfur bacteria.

Another feature of the fine sand is the occurrence in it of a 'zone' of biotite-rich sediment at approximately 20 to 30 fathoms. That is, a relatively large percentage of this mineral is characteristic of this depth, especially in the southern part of the bay. Approximately one to five per cent of the total sediment here is biotite. If an occurrence such as this could be checked from other basins, it might provide a reliable index for the interpretation of shallow deposits.

The very fine sand unit is a difficult one to interpret when the wet sediment is dredged, for then it has much the same consistency as the silt and clay (mud) unit. However, when dry the sediment is distinctly different from the mud type. Analyses of samples 11, 12, 26 (Fig. 10), 80, 83 (Fig. 12), 113 and 122 (Fig. 13) serve to illustrate the mechanical composition of the very fine sand.

The sediments so far considered have shown only a rough parallelism with the isobaths, or lines of equal depth, in regard to areal distribution. The area of mud, more properly spoken of as silt and clay, does not differ in this respect. However, in the main channel, it does approach relatively closer to the shore, and narrows the other units where they occur off-shore from Elkhorn Slough. The approximate upper limit of the muds is placed at the 30-fathom line.

The mud consists of the flocculated particles of silt and clay size. It is the proper dispersion of these flocculates that renders their analysis difficult. They are made up of approximately 60 per cent particles of silt size and 40 per cent of clay size, if one considers the area as a whole. There are variations from this, of course, and the detailed analyses are shown in graphs of samples from the mud area.

The silt and clay samples were inspected carefully for alternating differences in grain size or composition; the only change noticed was that due to oxidation of the ferrous sulfide in the uppermost part of the sediment to ferric hydroxide. This lamination in view of its unstable character could hardly be preserved in sediments.

However, by subjecting these fine-grained sediments to a pressure of 50 pounds per square inch it was possible to obtain a faint parting perpendicular to the direction of force. An insufficient number of undisturbed core samples were obtained to permit extensive experimentation, but the results obtained suggest that pressure rather than alternation in composition is the chief factor in causing shale fissility. The question has been more fully considered by Rubey[11] who has arrived at similar conclusions.

Rubey[12] has suggested that the environment which a fine-grained sediment has at the time of formation may be deduced from the mechanical analysis of the sediment: 'If . . . flocculation is decided to be the chief factor, the possibility suggests itself that saline

[11] Rubey, William W. Lithologic studies of fine-grained upper Cretaceous sedimentary rocks of the Black Hills Region. U. S. Geol. Survey Prof. Paper 165-A, p. 38, 1930.

[12] Rubey, William W., *op. cit.*, p. 31.

and fresh-water clays and shales may be distinguished by their degree of sorting.' As pointed out by Taylor,[13] there are a number of agencies capable of causing colloid coagulation. Many of them effect clays and the colloids associated with them, such as organic and ferric hydroxide, and the following list includes factors which may operate in both salt and fresh waters:

> "decrease in temperature (without freezing the medium) . . . freezing the medium . . . ; increase in temperature . . .; . . . mechanical stirring . . .; . . . 'salting out' by high concentrations of electrolytes . . .; dilute electrolytes . . .; . . . mutual coagulation of two hydrophobic sols; or mutual coagulation of a lyophobic and lyophilic sol."

Comber[14] has also mentioned a so-called 'anomalous' flocculation which may possibly operate in either fresh-or salt-water under special conditions.

It is somewhat hazardous, then, judging from this consideration, to attribute all flocculation to agencies operating in a salt-water medium. Some preliminary examinations of fresh-water sediments show that not only are the fine particles flocculated, but that the composition curves obtained by 'sedimentation' analysis are not distinctly different from those of the marine sediments reported on here. However, the question is by no means settled and requires more data.

The most interesting unit mapped is that which is limited to the deeper part of the submarine channels. This area, characterized by coarse sediment (gravel to fine sand, varying from station to station) overlying silt, apparently follows the valleys quite closely, although insufficient dredgings have been made to delimit the area exactly. Davidson's record of "boulders under the soft muddy bottom at 480 fathoms off Point Pinos"[15] would be of considerable value if the exact locality had been given. As it is, it is nothing more than a conjecture to use such information for arriving at an idea of the rate of accumulation of the sediments.

These stratified sediments and the neighboring gravel areas lying on the continental slope provide some data relating to the origin of the submarine valleys, although proponents of the various theories which account for the valleys may use the data as they desire. In brief, the stratified sediments contain recent marine organisms and their remains in both the silt and the overlying gravel or sand; Foraminifera, sponge spicules, and Radiolaria have been found in them. The same statement applies to the gravelly silts and sands which occur on the edges of the valley slopes. It is apparently impossible, then to interpret these sediments as being undisturbed river gravels. But the fact that the pebbles are of Franciscan chert, granite, basalt, Monterey opaline shale, and are well rounded, point to a long distance of transport. The writer has interpreted the occurrence of the gravels and sands as being reworked river or delta gravels. Lawson[16] and Holway[17] discussed the origin of these submarine valleys described by Davidson.

---

[13] Taylor, Hugh S. A treatise on physical chemistry. Vol. 2, 2nd ed. New York, p. 1695, 1931.

[14] Comber, Norman M. The mechanism of flocculation in soils. Trans. Farad. Soc., 17, pp. 349–368, 1921–1922.

[15] Davidson, George, The submerged valleys of the coast of California, U. S. A., and of Lower California, Mexico. Proc. Cal. Acad. Sci., 3rd ser., Geol., 1, p. 92, 1897.

[16] Lawson, A. C. The geology of Carmelo Bay, California. Univ. Calif. Publ., Bull. Dept. Geol., 1, p. 57, 1893.

Lawson, A. C. The continental shelf off the coast of California. Bull. Nat. Res. Council, 8, pt. 2, no. 44, 1924.

[17] Holway, R. S. Physiographically unfinished entrances to San Francisco Bay. Univ. Calif. Publ., Bull. Dept. Geog., 1, pp. 100–101, 1914.

It is possible that upwelling may account for the transportation of the gravel and sand which overlie the silt from the sediments occurring at higher levels on the slopes. That is, upwelling currents might produce a turbulence, creating currents strong enough to disturb and transport sediments from higher to lower levels, or even carrying fine sediments to higher elevations. McEwen's[18] computations show a negligible current due to upwelling, and the recent findings of the Hydrobiological Survey indicate that the water over the main part of the channel is arranged in static layers.[19]

Chemical Investigations.

Formation of Black and Brown Muds.

The problem of the distribution of hydrotroilite, which is a black, amorphous, hydrous sulfide of iron, in recent sediments has a geological bearing, for this mineral may be considered in one case a progenitor of pyrite,[20] in the other the first stage in the formation of hydrous and anhydrous ferric oxides—depending, of course, upon the environment of a sediment at the time of, and subsequent to, its deposition. Apart from giving an indication as to the geologic history of an ancient sediment, the presence, or former presence, of products connected with the sulfur cycle affords a means whereby postulates may be advanced regarding the conditions which control a process of considerable geologic interest, that of oil formation; for Thayer[21] suggests that:

> "in the absence of sufficient sulfate, the sulfate-reducing bacteria may be able to reduce the fatty acids, and indeed other organic matter; and finally, that the anaerobic decomposition of the pigments (of diatoms), which are largely hydrocarbon in nature may lead to the formation of petroleum-like compounds."

The reactions which take place during the progress of the sulfur cycle are the results of the activities of several different groups of organisms. Plants, building up organic compounds by photosynthesis, furnish the ultimate source of energy for all but certain autotrophic bacteria. Sulfur, the element of chief concern here, is compounded chiefly in plants as proteins (see Fig. 9A). These plant proteins, in turn, may follow two different courses: They may be directly decomposed by bacterial activity; or they may be converted into proteins of animal bodies, and these also, may become consumed in the metabolism of bacteria. Liberation of considerable hydrogen sulfide accompanies the decomposition of the proteins by heterotrophic bacteria; that is, organisms which "have to depend for their energy supply upon complex organic or carbonaceous substances."[22]

Hydrogen sulfide, and sulfur as well, is also supplied by the reduction of sulfates during metabolism of the sulfate-reducing microorganisms. The production of sulfide marks the major step in the cycle. From here the reactions may proceed different ways. The

[18] McEwen, G. F. The distribution of ocean temperatures, etc. Int. Rev. Ges. Hydrobiol. Hydrogr., 5, pp. 243–286, 1912.

[19] Oral communication from Mr. Rolf Bolin.

[20] Newhouse, W. H. Pyrite concretions in coal and other rocks. Journ. Geol., 35, pp. 73–83, 1927.

Galliher, E. Wayne. Collophane from Miocene brown shales of California. Bull. Amer. Assoc. Petrol. Geol., 15, pp. 257–269, 1931, pp. 267–269.

[21] Thayer, Lewis A. Bacterial genesis of hydrocarbons from fatty acids. Bull. Amer. Assoc. Petrol. Geol., 15, p. 453, 1931.

[22] Waksman, Selman A. Principles of soil microbiology. Baltimore, p. 408, 1927.

hydrogen sulfide and soluble ferrous salts precipitate, by double decomposition, ferrous sulfide as a hydrous mineral. Furthermore, since hydrogen sulfide is a reducing agent, available ferric iron is reduced to ferrous iron and the reduction is accompanied by the oxidation of the sulfide to free sulfur, as well as by the precipitation of hydrotroilite.

The most important link of the sulfur scheme is that designated in Fig. 9A as the anaerobic sulfate-hydrogen sulfide phase.

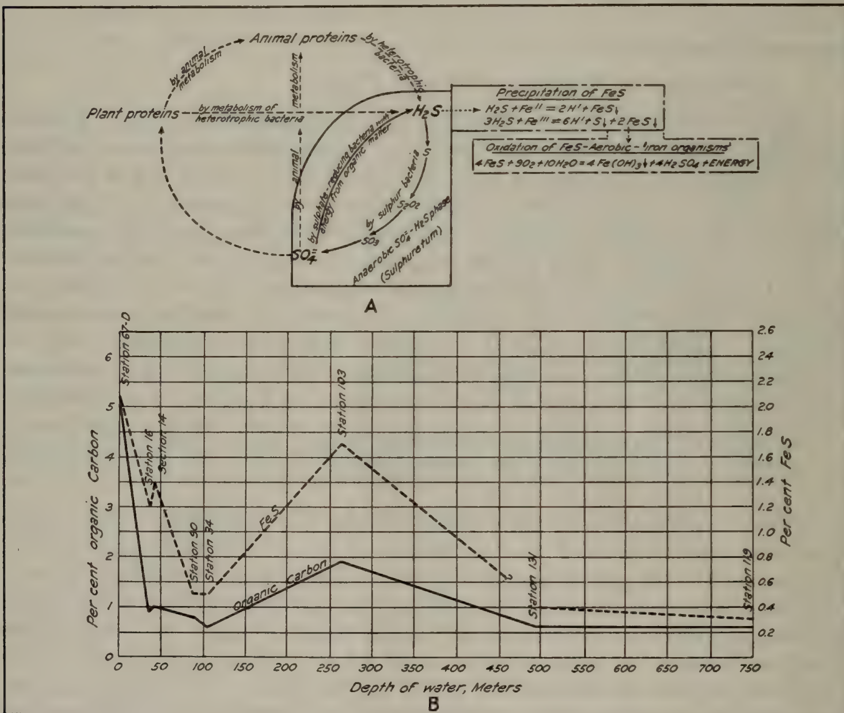


FIG. 9. A. Schematic diagram of natural sulfur cycle showing reactions which take place in bottom sediments. Reactions relating to the formation of ferrous sulfide and its oxidation to ferric hydroxide pertain especially to the formation of black muds and the red layer overlying them.

B. Graph of data showing variation of amount of organic matter and ferrous sulfide with depth of water of their occurrence. Under certain conditions the amount of ferrous sulfide which colors a sediment black is indirectly a function of the amount of organic matter which is available. Organic carbon is used as an index of total organic matter.

The black-mud community, which includes various types of microorganisms, has been designated the sulfuretum[23] and will be used in the present paper as another designation for the locale of this anaerobic sulfate-hydrogen sulfide phase of the sulfur cycle.

The cycle of sulfate to sulfide to sulfate continues as long as organic matter is present and, more important, as long as sulfate is available for the metabolism of the sulfate-reducing microorganisms. Sea-water offers an unlimited supply of sulfate and the development of black mud in marine basins should depend on the availability of

[23] Becking, L. G. M. Bass. Studies on the sulfur bacteria. Ann. Bot., 39, pp. 613–650, 1925. p. 614.

carbonaceous detritus. The black mud is a reserve of iron sulfide, and hydrogen sulfide is made available by the organisms through local acidification.

It is not amiss to show the correlation between ferrous sulfide and the organic content of the black muds from various stations—this is shown in Fig. 9B. It has been impossible to determine all the complex organic compounds present in the samples. Therefore total organic carbon has been used as an index of total organic matter.

To generalize from the data shown in the curve there is a decrease in carbon and sulfide with increase in depth, although the variation is not exact. However, it is justified by contrasting the intense black muds of the shallower regions (0–40 meters) with the blue-gray muds of the greater depths (700–800 meters).

Darker Color Accompanies Increase in Sulfide Content.

Another factor besides available organic matter to be considered in regard to sulfide formation is that of bottom temperatures. Sulfate reducers withstand temperatures from 0° to 80°C. The bottom temperature of the water at the deepest dredging (station 119) varies from 4° to 5° C. At these lower temperatures the rate of sulfide formation is reduced, but there is no reason for assuming that the amount of sulfide should be less, given an equal quantity of organic matter. Certainly the time limit for sulfide formation is amply satisfied, and we may consider the sulfide content of a given mud as very probably the maximum for that depth, with that content of organic matter.

The alkaline environment in the sulfide mud is of considerable interest. R. C. Moore[24] in a discussion of the environment of Pennsylvanian times states:

> "An acid and toxic environment is indicated by the nature of the plant débris, the presence of sulfides. . . ."

If he bases this statement on analogy with conditions in recent sediments, he is in error. Be the sulfides syngenetic or secondary, they bear no evidence for acid conditions. The anaerobic phase is carried on in an alkaline milieu. The following series of pH[25] readings of the black mud in Monterey Bay show that the milieu is alkaline and maintains the stability of the sulfide precipitate:

Station	*Depth of water, meters*	*pH*
67-B	0.5	8.6
15	76	8.7
90	88	8.2
103	265	8.4
131	492	8.1

It is only upon oxidation that the milieu becomes acid; then sulfide formation ceases. In this regard Bruce[26] states:

> "In all cases, the filtrate from the dark layers, originally clear, became opalescent on exposure to the air, and the pH fell."

[24] Moore, R. C. Environment of Pennsylvania life in North America. Bull. Amer. Assoc. Petrol. Geol., 13, pp. 459–487, 1929. p. 465.

[25] pH is merely a means of measuring the concentration of free hydrogen ions in a solution. Seven is taken as the neutral point. Figures greater than seven indicate alkalinity; those less than seven, acidity.

[26] Bruce, J. Ronald. Physical factors on the sandy beach. Part II. Chemical changes, carbon dioxide concentration and sulfides. Journ. Mar. Biol. Assoc., 15, pp. 553–565, 1928.

The lower limit of his pH values is not stated, but the writer has found the milieu to change from 8.8 to 6.2 (maximum range for a given sample). Meehan and Becking[27] have noted a change from pH 7.6 to 6.8. This shift *which occurs on aeration*, and is caused by the formation of organic as well as mineral acids, is accompanied by the oxidation of the ferrous iron. The iron oxidation liberates energy which is used by a group of micro-organisms living in the brown oxidized layer overlying the black mud.

The assemblage of 'iron organisms' living in the brown layer is somewhat complex. Harder[28] has divided the iron bacteria, and discussed the geological importance of the following groups:

1. Autotrophic, those to which the oxidation of ferrous iron provides a source of energy for the assimilation of CO_2.
2. Heterotrophic, those which precipitate ferric hydroxide or basic ferric salts from organic iron salt solutions (such as citrate) by the assimilation of the organic acid radical.
3. Facultative autotrophic, those which deposit ferric hydroxide when either organic or inorganic iron salts are present and which do not need ferrous bicarbonate for metabolism. The inorganic iron salts, however, can not be used as sources of energy.

There is some doubt as to the correctness of these divisions. Such a question lies outside the scope of this paper, but it should be pointed out that Meeham and Becking[29] have suggested that several of the 'thread bacteria' mentioned by Harder are probably identical, and that these thread bacteria are only the gelatinous stalks of a protozoan.

It should be added that the micro-organisms are not considered as *instrumental* in the oxidation of the iron. Rather, that they are present to utilize energy liberated by the oxidation which would proceed unaided in aerobic conditions. In other words, the change from ferrous to ferric iron liberates a certain amount of energy which a group of micro-organisms can utilize. From a geological point of view, then, they become important as localizers of ferric iron precipitation. That is, by forming sheaths of iron hydroxide around the cells these organisms build a matte, more or less gelatinous at first, but which may become indurated. Harder[30] describes these accumulations in considerable detail. He also, along with Harder and Chamberlin[31], Ellis,[32] and Gruner,[33] discusses adequately the possible rôles the iron organisms have played in the formation of some of the most important sedimentary iron ores.

Occurrence of Carbonate in Sediments.

The statement made by Sudry[34] regarding the distribution of carbonates in the sediments of the Thau basin, near Cette, southern France, apparently holds equally well for the Monterey Bay sedi-

[27] Meehan, William J., and L. Bass-Becking. Iron organisms. Science, n. s., 66, p. 42, 1927.

[28] Harder, Edmund Cecil. Iron-depositing bacteria and their geological relations. U. S. Geol. Survey Prof. Paper 113, 1919.

[29] Meehan and Becking, *op. cit.*

[30] Harder, Edmund Cecil. *op. cit.*

[31] Harder, E. C., and R. T. Chamberlin. The geology of central Minas Geraes, Brazil. Journ. Geol., 23, pp. 385–415, 1915.

[32] Ellis, D. Iron bacteria. London, 1919.

[33] Gruner, John W. The origin of sedimentary iron formations. Econ. Geol., 17, pp. 407–460, 1922.

[34] Sudry, Louis. L'Etang de Thau. Ann. L'Inst. Oceon. Tome 1, Fasc. 10, p. 135, 1910.

ments reported on here. He said that the proportion of carbonate increases in the vicinity of rocks, where shell débris accumulates by being drifted to topographically sheltered areas.

Sudry has even gone so far as to construct a map showing areas of equal carbonate distribution. Such a map serves well to show the general relation between the sediments of high carbonate content and their occurrences near points, ledges, or gravel bars both exposed and submerged. However, the very erratic distribution of such sediments near the exposed points and the lack of detailed data concerning the carbonate content of the submarine ledges and bars make it seem to the writer a bit far-fetched to show in black and white the per cent of carbonate in a sediment over a large area, especially on a large scale map. For example, station number 51 which is pictured in Fig. 2 is a shell deposit 78 per cent of which is soluble in acid and represents calcium carbonate. Less than 100 yards away in either direction the carbonate drops to 5 to 10 per cent of the sands. Between these stations there are spots entirely free of carbonate sediments and some which are covered with practically pure shell-beds. It is impossible to represent such variations on the ordinary map with any degree of accuracy. It is likewise impossible to judge from one or two samples dredged from a submerged reef or bar the distribution of carbonate in all the associated sediments. The writer can give, then, only a rough indication of the manner in which calcareous materials constitute or help constitute the deposits in Monterey Bay.

All or practically all, the carbonate matter in the sediments is of mechanical origin; that is, due to the accumulation of shells, entire or broken, or their levigated products. The highest percentage of such material in the sediment is found along the shore at, or on the lee side of, those points which are exposed to strongest wave action. The illustration in Fig. 2 is representative. Off-shore samples, such as 28, 141, and 142 in the southern end of the area mapped (see lithologic chart), may even show quantities of carbonate as high as 66 per cent. However, there is a general decrease in carbonate content with increase in depth of water and samples from the fine sand and mud areas, such as numbers 10, 12, 91, 113, 147 usually show less than one per cent. Some of the deeper samples, as 35 and 109 from 54 and 25 fathoms, respectively, may show ranges of 5 to 10 per cent. But these samples from submerged 'ledges' probably represent the accumulation of shell débris from jutting rock outcrops.

Another area where a slight increase in carbonate is evident is in a zone which may be called the *Dendraster excentricus* zone. This area, marked by the abundance of this 'sand-dollar,' is roughly outlined by the 5 and 20 fathom contour lines along the sandy shore south of Elkhorn Slough, and the 5 and 10 fathom lines along the shore north of Elkhorn Slough. Here again, the occurrence of these calcareous organisms is sporadic, but many of the samples in these zones contain large amounts of them. The empty tests, both entire and partially broken, may contribute carbonate material to the sediment to the extent of 5 to 10 per cent.

The total carbonate, allotted as calcium carbonate, of the analyzed samples is tabulated at the end of the report.

Distribution of Phosphates in Sediments.

The occurrence of phosphates in marine sediments is of some interest to both geologist and biologist. To the former, data concerning the phosphate content of recent deposits may be of assistance in interpreting the origin of some of the sedimentary phosphate rocks as, for instance, parts of the well-known Phosphoria formation of southeastern Idaho.[35] To the latter, the phosphates of a sediment are important in relation to the organisms which live therein and utilize the food materials in the sediment.[36] The writer found that it would take more time than he had available to make detailed analyses of the vertical distribution of phosphates in tube-samples of each station. Data such as these are interesting biologically, but to obtain them requires an extraordinary amount of time and the use of very careful analytical methods. Three preliminary trials showed that the maximum variation in a core of the fresh sediment was 0.04 per cent P_2O_5 between the top of the core and eight to ten centimeters down. Since the phosphate contents of the samples are expressed to the nearest tenth of one per cent in this report, variations such as the above are included; and the use of a limit of accuracy of this degree has made it possible to analyze a large number of samples (collected by both the tube and clam-shell dredges).

The interesting fact about the Monterey Bay sediments, so far as the present analyses have been carried, is that their phosphate content falls below one per cent P_2O_5. The only exceptions noted can not be considered as belonging in the bay proper; samples 67C and 67D, from Elkhorn Slough, with contents of 0.8 and 1.3 per cent P_2O_5, respectively, are somewhat high and it is probable that the abnormality is due to artificial contamination. Sample number 19 from the south end of the bay showed 0.8 per cent P_2O_5 which is also higher than many of the others. The nearness of sample 19 to the fish markets, and fish canneries, which are grouped rather closely along the southern shore in this vicinity, make it probable that here also the high phosphate content of the sediment is due to artificial pollution; that is, by waste products from canning processes.

It is unnecessary to repeat all the phosphate data here, for they are given in tabulated form at the end of this report. A plot of the data shows no correlation of depth of water and phosphate content of the sample, nor with texture of the sediment. The average of all the samples from the bay proper is approximately 0.15 per cent P_2O_5.

Data for comparison with those given above are not very extensive if one consider shallow water marine sediments only. Moore[37] report 0.10 to 0.36 per cent P_2O_5 from the Clyde Sea area, Scotland. Thi area, characterized by shallow, tide-swept estuaries, has nearly th same chemical picture in regard to sedimentary phosphates as Montere Bay. Goldman[38] shows much less than one per cent P_2O_5 in the cal careous sediments from the Bahama Islands reefs. Sudry,[39] howeve

[35] Mansfield, George Rogers. Geography, geology, and mineral resources c part of southeastern Idaho. U. S. Geol. Survey Prof. Paper 152, 1927.

[36] Moore, H. B. The muds of the Clyde Sea area. I. Phosphate and nitroge contents. Journ. Mar. Biol. Assoc., 16, pp. 595–607, 1930.

[37] Moore, H. B. *op. cit.*, p. 598.

[38] Goldman, M. I. Proportions of detrital organic constituents and thei chemical alteration in a reef sand from the Bahamas. Carn. Inst. Wash. Pub. N 344, pp. 37–66, 1926.

[39] Sudry, Louis. *op. cit.*, p. 139.

gives rather high values for phosphates in the sediments of the Thau basin, southern France. Variations of 1.19 to 4.10 per cent are recorded by him. Sudry indicates that the phosphate content of the sediment increases as the content of organisms increases. Hence, since the high phosphate content is natural, the possibility is suggested that phosphate-rich marine sediments tend to accumulate in closed (or nearly closed) basins, such as the Thau lagoon.

SUMMARY OF CONCLUSIONS

Monterey Bay is an open marine basin of deposition, characterized by the presence of a group of submarine channels. These channels have a profound influence on the distribution and nature of the sediments of the bay which are all terrigenous, that is, derived from the land. Wave action, controlled by wind force, has an especially marked effect on the distribution of some of the littoral sands, shore deposits.

Five different kinds of sediments, deposited under different environments, are found in areas located not far apart: marine sediments of the bay proper; wind deposits which form a thin strip bordering the shore; estuarine deposits of small extent and sporadic distribution; fresh water or brackish water sediments, such as those of the lakes near Del Monte and Seaside; and sediments of special environments, such as those of the saline lakes near the town of Marina. These saline lakes have biological and chemical affinities to true desert salines. In this report only the marine sediments of Monterey Bay have been described in detail.

In general, the average grain-size of the sediments has been found to decrease with increase in depth of water. The different sediments are distributed roughly in areas parallel to the isobaths, or lines of equal depth which are shown on the accompanying map. Gravels have been found in the center of and bordering the submarine valleys. These gravels are probably reworked from river or delta deposits, originally transported from the bordering Coast Ranges.

The bacteria which are instrumental in forming the black muds of the sea-floor, and which may participate in the formation of petroleum-like compounds, operate in an alkaline environment. The presence of ferrous sulfide which colors the muds black, blue, and gray is dependent on bacterial action, and is shown to be roughly correlated with the amount of organic matter in the sediments. These facts apparently agree with the present concept of the natural sulfur cycle, described in the body of this report. The oxidation of the ferrous sulfide liberates energy which supports another group of microorganisms of the overlying brown muds.

In Monterey Bay, sediments with high carbonate content accumulate near rocky points and submarine ledges. These particular sediments, characterized by organic shell-débris of mechanical origin, are limited in extent.

The phosphate content of the sediments of Monterey Bay has not been found to exceed one per cent phosphorous pentoxide, whereas sediments of the Thau lagoon, southern France, have a high phosphate content. The possibility is suggested that phosphate-rich deposits tend to accumulate in basins, which are almost entirely shut off from the sea.

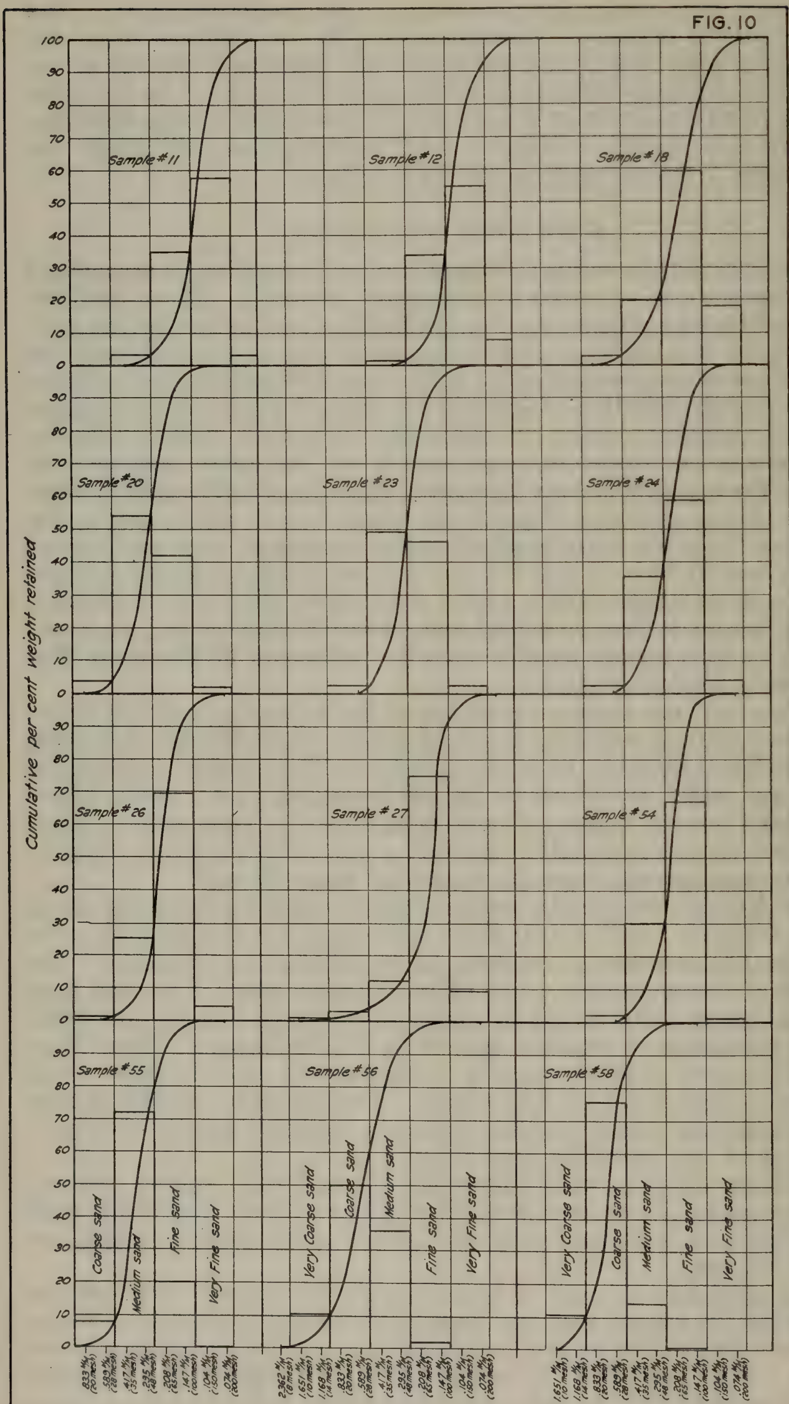


FIG. 10. Graphic representation of screen analyses. *Explanation of chart:* The lines which run the length of the page show mesh of screen and size of mesh-openings. The lines which run the width of the page show the per cent of the weight of the sample whose particles each have a diameter smaller than the mesh-opening indicated. The smooth curve which results from plotting is called a 'cumulative' curve. The areas blocked out with heavier lines are called 'histograms' and show the amount of material which has dimensions between certain arbitrary limits. They serve to characterize the sediment as 'coarse sand,' 'medium sand,' etc. The limiting dimensions may be found on Plate III.

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
1	36° 55′ 03″	121° 55′ 30″	10/15/30	14	Fine green sand	0.2	0.4	
2	36° 55′ 18″	121° 55′ 26″	10/15/30	12	Fine green sand	x	0.3	--------
3	36° 55′ 33″	121° 55′ 03″	10/15/30	12	Fine green sand	0.3	0.1	--------
4	36° 41′ 48″	121° 49′ 12″	11/ 3/30	14	Fine gray sand	0.5	0.1	--------
5	36° 41′ 23″	121° 49′ 42″	11/ 3/30	27	Fine olive-gray sand	0.4	0.4	--------
6	36° 38′ 33″	121° 53′ 20″	11/ 3/30	40	Fine green sand	0.3	0.1	--------
7	36° 39′ 03″	121° 52′ 14″	11/12/30	31	Fine green sand	x	x	--------
8	36° 37′ 42″	121° 53′ 43″	12/ 5/30	20	Fine olive sand	0.2	0.2	--------
9	36° 38′ 23″	121° 53′ 28″	12/ 5/30	30	Very fine green sand	0.4	0.1	--------
10	36° 38′ 58″	121° 53′ 20″	12/ 5/30	38	Very fine green sand	0.2	0.3	--------
11	36° 39′ 26″	121° 53′ 09″	12/ 5/30	39	Very fine green sand	0.7	0.2	10
12	36° 40′ 00″	121° 52′ 56″	12/ 5/30	41	Very fine green sand	0.3	0.4	10
13	36° 40′ 46″	121° 52′ 37″	12/ 5/30	44	Fine green sand	0.2	0.1	--------
14	36° 41′ 43″	121° 52′ 36″	12/ 5/30	42	Vetiver green silt	0.4	0.3	15
15	36° 42′ 23″	121° 52′ 12″	12/ 5/30	42	Vetiver green silt	0.6	x	15
16	36° 43′ 03″	121° 51′ 52″	12/ 5/30	37	Vetiver green silt	0.5	x	15
17	36° 43′ 56″	121° 51′ 27″	12/ 5/30	30	Very fine olive sand	0.3	0.4	15
18	36° 36′ 54″	121° 53′ 33″	12/ 5/30	17	Fine gray sand	0.6	0.6	10
19	36° 36′ 20″	121° 53′ 28″	12/ 5/30	3	Fine gravelly gray sand	0.4	0.8	--------
20	36° 58′ 05″	121° 54′ 09″	12/12/30	*	Medium gray sand	0.4	x	10
21	36° 57′ 28″	121° 53′ 14″	12/12/30	------	Medium gray sand	0.2	x	--------
22	36° 57′ 02″	121° 52′ 42″	12/12/30	------	Medium gray sand	0.4	x	--------
23	36° 56′ 27″	121° 52′ 08″	12/12/30	------	Medium gray sand	0.2	x	10
24	36° 55′ 52″	121° 51′ 38″	12/12/30	------	Fine gray sand	0.1	x	10
25	36° 54′ 45″	121° 50′ 57″	12/12/30	------	Fine gray sand	0.3	x	--------
26	36° 53′ 45″	121° 50′ 16″	12/12/30	------	Fine gray sand	x	x	10
27	36° 38′ 10″	121° 54′ 30″	12/22/30	25	Fine gray sand	24.6	0.4	10
28	36° 38′ 41″	121° 55′ 08″	12/22/30	23	Shell gravel	66.1	0.2	--------
29	36° 39′ 34″	121° 56′ 16″	12/22/30	41	Fine gray sand	6.3	0.3	--------

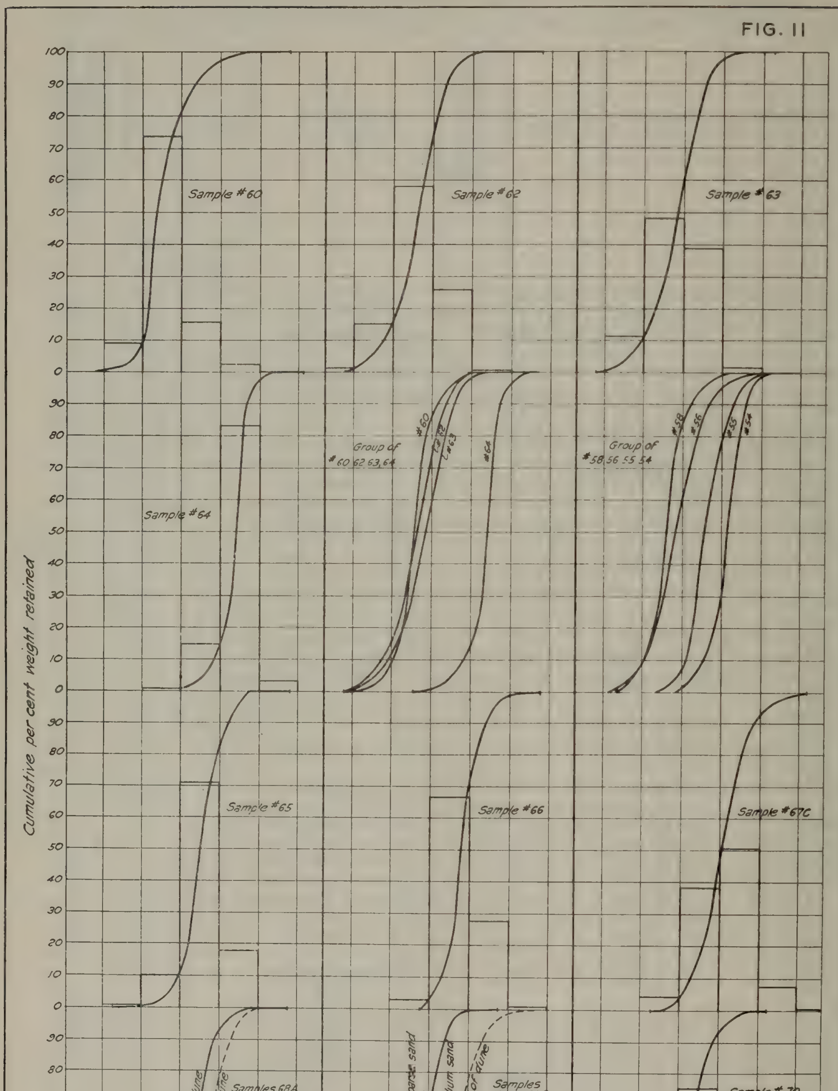


FIG. 11. Screen, or mechanical, analyses of samples 60, 62, 63, 64, 65, 66, 67C, 68A and B, 69A and B, and 70. The explanation given for Fig. 10 applies here also. Samples 60 to 64, and 58 to 54 are grouped together to show the variation of texture of the sand along the beach. The three samples of wind deposits are represented by samples 68, 69, and 70. Samples 68 and 69 which come from

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
30	36° 40′ 06″	121° 57′ 02″	12/22/30	55	Fine green sand	2.1	x	--------
31	36° 40′ 14″	121° 58′ 08″	12/22/30	59	Fine olive sand	0.3	x	--------
32	36° 40′ 40″	121° 58′ 55″	12/22/30	62	Very fine olive sand	0.2	0.3	--------
33	36° 41′ 29″	121° 59′ 12″	12/22/30	63	Very fine olive sand	0.2	0.2	--------
34	36° 41′ 35″	121° 58′ 03″	12/22/30	58	Very fine green sand	2.2	0.5	--------
35	36° 41′ 46″	121° 56′ 39″	12/22/30	54	Medium olive sand	10.8	0.2	--------
36	36° 40′ 56″	121° 56′ 09″	12/22/30	50	Very fine olive sand	0.6	0.2	--------
37	36° 37′ 38″	121° 54′ 58″	12/22/30	------	Coarse gray sand	4.3	0.3	--------
38	36° 37′ 46″	121° 55′ 15″	1/10/31	------	Coarse sand and gravel	9.2	0.2	14
38A	36° 37′ 46″	121° 55′ 15″	1/10/31	------	Coarse sand and gravel	15.3	x	--------
39	36° 38′ 15″	121° 55′ 45″	1/10/31	------	Coarse gray gravel	2.0	x	--------
40	36° 38′ 15″	121° 56′ 10″	1/10/31	------	Coarse gray gravel	12.5	0.4	14
41	36° 37′ 56″	121° 56′ 17″	1/10/31	------	Coarse gray gravel	8.6	0.2	--------
42	36° 37′ 27″	121° 56′ 24″	1/10/31	------	Coarse gray gravel	6.7	x	--------
43	36° 38′ 45″	121° 54′ 04″	1/12/31	38	Medium gray sand	1.8	0.2	--------
44	36° 39′ 32″	121° 54′ 16″	1/12/31	47	Fine green sand	0.6	x	--------
45	36° 40′ 31″	121° 54′ 32″	1/12/31	54	Very fine green sand	0.8	0.3	--------
46	36° 41′ 28″	121° 54′ 36″	1/12/31	50	Olive silt	0.4	x	--------
47	36° 42′ 38″	121° 54′ 30″	1/12/31	47	Dark green silt	0.6	0.7	15
48	36° 37′ 18″	121° 54′ 33″	1/27/31	------	Coarse sand and gravel	4.1	0.2	--------
49	36° 37′ 24″	121° 54′ 43″	1/27/31	------	Coarse sand and gravel	3.2	x	--------
50	36° 37′ 15″	121° 54′ 20″	4/ 3/31	------	Coarse sand and gravel	8.3	0.3	--------
51	36° 37′ 20″	121° 54′ 12″	4/ 3/31	------	Shell gravel	77.8	0.5	--------
52	36° 36′ 52″	121° 54′ 51′	4/ 3/31	------	Coarse gray sand	2.0	x	14
53	36° 36′ 30″	121° 51′ 30″	6/23/31	------	Fine sand from brackish lake	x	x	--------
54	36° 36′ 04″	121° 53′ 04″	1/28/31	------	Fine buff sand	0.9	x	10
55	36° 36′ 21″	121° 52′ 10″	1/28/31	------	Medium gray sand	0.2	x	10

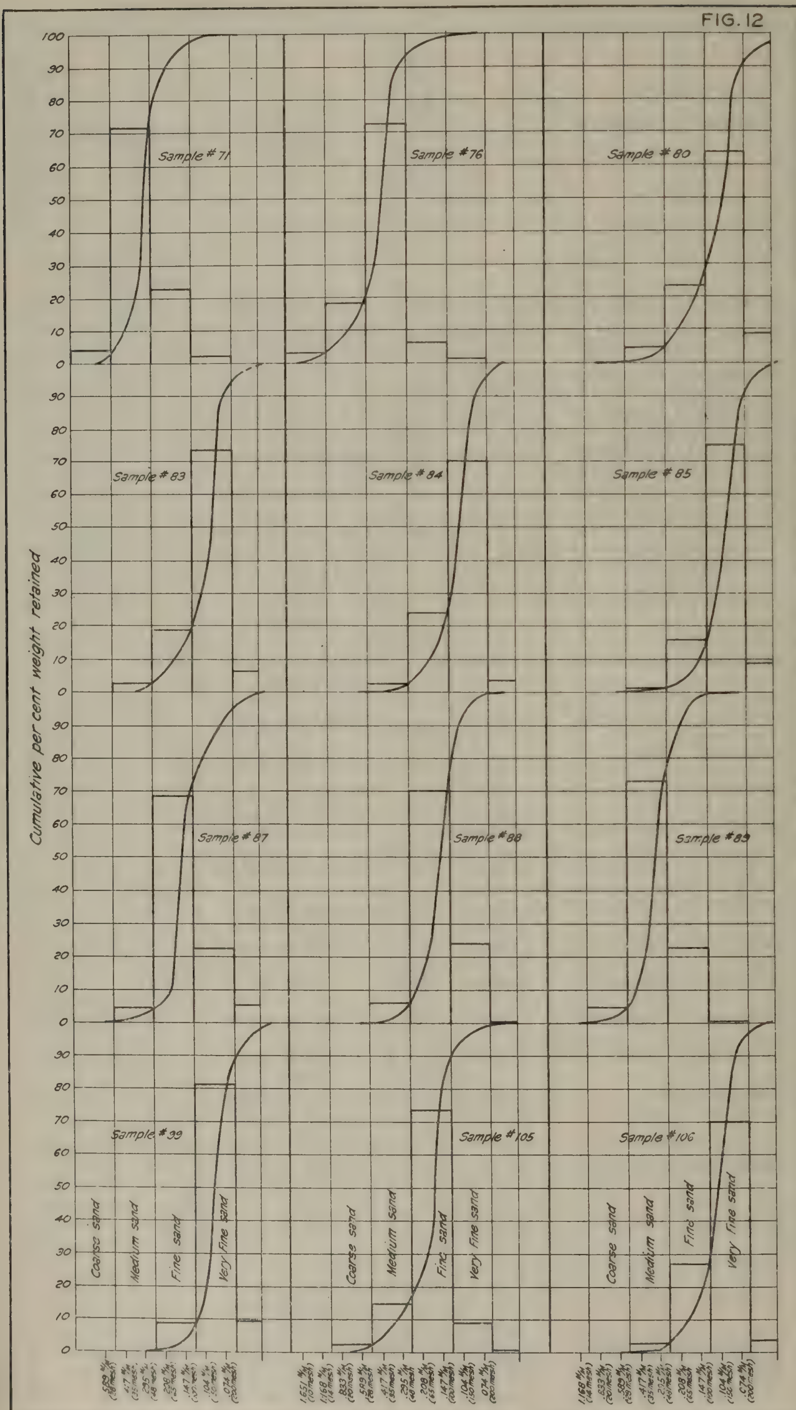


FIG. 12. Mechanical analyses of samples 71, 76, 80, 83, 84, 85, 87, 88, 89, 99, 105, and 106. The explanation of the graphs given in Fig. 10 apply here as well. All the samples in this group are water-laid and characterized by very good sorting.

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
56	36° 36′ 56″	121° 51′ 19″	1/28/01	------	Coarse buff sand	x	x	10
57	36° 37′ 33″	121° 50′ 43″	1/28/31	------	Coarse buff sand	x	x	--------
58	36° 38′ 26″	121° 50′ 06″	1/28/31	------	Coarse buff sand	x	x	10
59	36° 39′ 47″	121° 49′ 21″	1/28/31	------	Coarse buff sand	0.3	x	--------
60	36° 41′ 03″	121° 48′ 50″	1/28/31	------	Coarse buff sand	x	x	11
61	36° 42′ 50″	121° 48′ 26″	1/28/31	------	Coarse buff sand	x	x	--------
62	36° 44′ 02″	121° 48′ 24″	1/28/31	------	Coarse buff sand	0.5	x	11
63	36° 46′ 37″	121° 47′ 48″	4/ 7/31	------	Coarse buff sand	x	x	11
64	36° 48′ 02″	121° 47′ 21″	2/15/31	------	Fine buff sand	x	x	11
65	36° 50′ 48″	121° 48′ 28″	2/15/31	------	Medium gray sand	0.3	x	11
66	36° 52′ 30″	121° 49′ 27″	2/15/31	------	Medium gray sand	0.2	x	11
67A	36° 48′ 39″	121° 47′ 10″	2/25/31	------	Medium gray sand	0.3	x	--------
67B	36° 48′ 39″	121° 47′ 10″	2/25/31	------	Medium gray sand	x	------	--------
67C	36° 48′ 50″	121° 47′ 14″	2/25/31	------	Fine brown sand	x	0.8	11
67D	36° 48′ 47″	121° 46′ 44″	4/30/31	------	Black mud	x	1.3	--------
68A	36° 42′ 55″	121° 48′ 03″	4/30/31	------	Medium sand, windward side of dune	------	------	11
68B	36° 42′ 55″	121° 48′ 03″	4/30/31	------	Medium sand, lee side of dune	------	------	11
69A	36° 40′ 00″	121° 48′ 56″	4/30/31	------	Coarse sand, windward side of dune	------	------	11
69B	36° 40′ 00″	121° 48′ 56″	4/30/31	------	Medium sand, lee side of dune	------	------	11
70	36° 38′ 02″	121° 56′ 10″	4/30/31	------	Medium sand, small dune	------	------	11
71	36° 58′ 42″	121° 55′ 45″	1/30/31	------	Medium gray sand	0.8	x	12
72	36° 58′ 15″	121° 57′ 10″	1/30/31	------	Medium gray sand	1.5	------	--------
73	36° 57′ 18″	121° 58′ 21″	1/30/31	------	Coarse sand and gravel	3.1	0.2	14
74	36° 57′ 45″	121° 59′ 54″	1/30/31	------	Coarse sand and gravel	3.6	x	--------
75	36° 37′ 00″	121° 53′ 15″	2/ 2/31	15	Fine green sand	0.5	------	--------
76	36° 37′ 58″	121° 52′ 33″	2/ 2/31	26	Medium gray sand	5.4	x	12

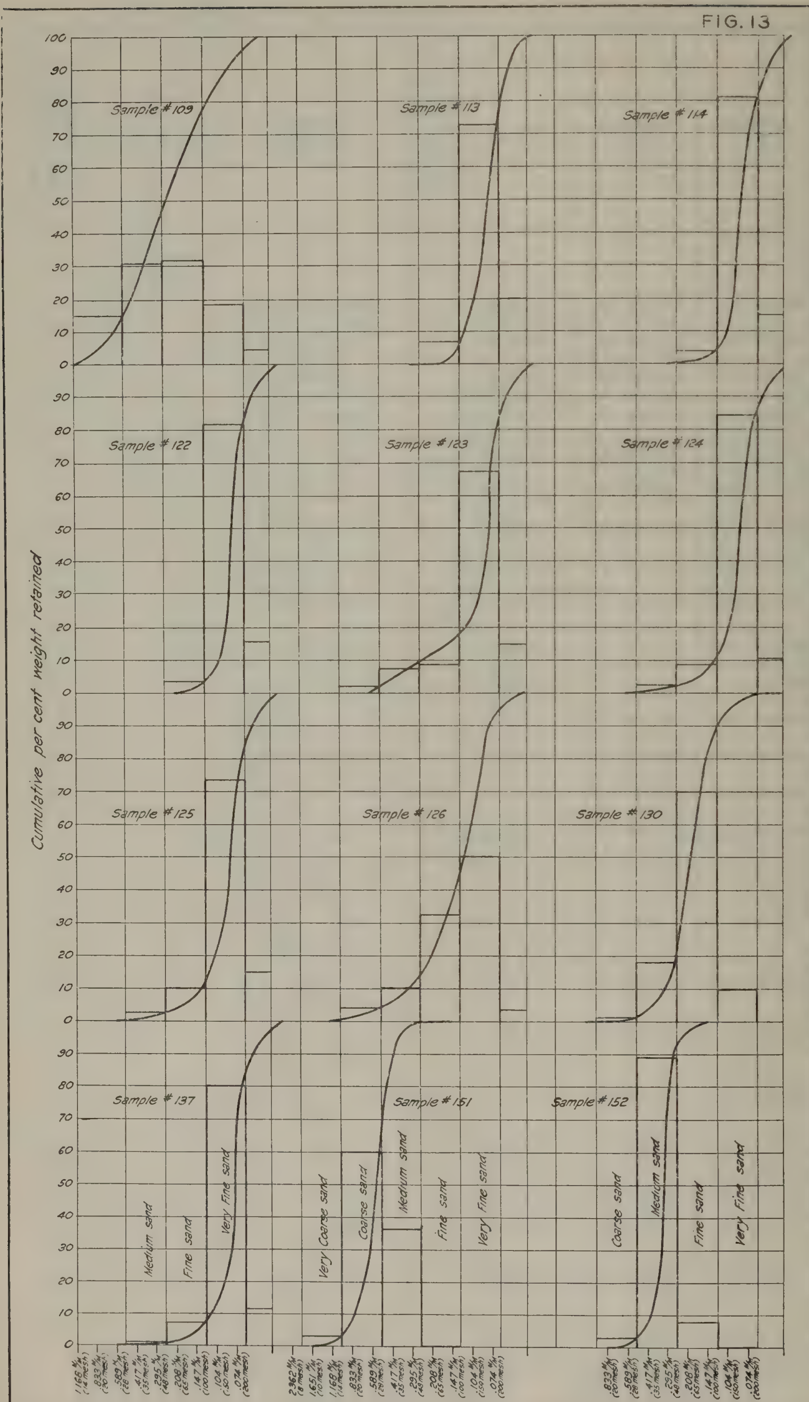


FIG. 13. Screen analyses of samples 109, 113, 114, 122, 123, 124, 125, 126, 130, 137, 151, and 152. All the samples are well or fairly well sorted with the exception of No. 109 which shows a large variation in particle size. This sample is typical of the gravel areas near the continental slope and fishing-grounds shown on Plate III.

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
77	36° 40′ 04″	121° 51′ 43″	2/ 2/31	31	Fine green sand	0.3	0.2	--------
78	36° 41′ 02″	121° 51′ 15″	2/ 2/31	33	Fine green sand	0.2	x	--------
79	36° 42′ 15″	121° 50′ 57″	2/ 2/31	30	Very fine green sand	0.5	------	--------
80	35° 43′ 15″	121° 50′ 20″	2/ 2/31	20	Very fine gray sand	6.3	x	12
81	36° 44′ 30″	121° 50′ 15″	2/ 2/31	15	Fine gray sand	4.3	------	--------
81A	36° 44′ 42″	121° 50′ 24″	2/ 2/31	14	Very fine gray sand	3.8	0.3	--------
82	36° 45′ 42″	121° 50′ 21″	2/ 2/31	21	Very fine gray sand	0.2	x	--------
83	36° 45′ 00″	121° 49′ 15″	2/ 2/31	10	Very fine gray sand	2.2	x	12
84	36° 44′ 08″	121° 49′ 18″	2/ 2/31	10	Very fine gray sand	x	------	12
85	36° 43′ 14″	121° 49′ 27″	2/ 2/31	15	Very fine gray sand	0.4	x	12
86	36° 42′ 36″	121° 50′ 00″	2/ 2/31	21	Very fine gray sand	------	------	--------
87	36° 40′ 14″	121° 50′ 39″	2/ 2/31	24	Fine olive sand	0.2	0.1	12
88	36° 39′ 12″	121° 50′ 45″	2/ 2/31	16	Fine gray sand	5.1	0.3	12
89	36° 37′ 48″	121° 51′ 39″	2/ 2/31	16	Medium buff sand	1.8	0.4	12
90	36° 41′ 03″	121° 53′ 38″	3/ 6/31	48	Green silt	0.6	x	16
91	36° 42′ 48″	121° 53′ 34″	3/ 6/31	43	Green silt	0.9	0.4	--------
92	36° 44′ 45″	121° 53′ 20″	3/ 6/31	48	Green silt	0.8	0.3	--------
93	36° 45′ 04″	121° 55′ 50″	3/ 6/31	60	Gravel and green silt	0.5	x	14
94	36° 43′ 18″	121° 57′ 51″	3/ 6/31	63	Gravel and green silt	0.7	0.4	--------
95	36° 43′ 48″	121° 55′ 00″	3/ 6/31	54	Green silt	3.3	x	--------
96	36° 42′ 04″	121° 56′ 18″	3/ 6/31	54	Green silt	1.2	x	--------
97	36° 37′ 08″	121° 52′ 58″	3/ 6/31	21	Coarse shell sand	6.0	------	14
98	36° 48′ 26″	121° 48′ 15″	3/ 6/31	44	Very fine green sand	1.9	x	--------
99	36° 51′ 04″	121° 50′ 08″	3/ 6/31	11	Very fine green sand	0.5	0.2	12
100	36° 48′ 14″	121° 49′ 00″	6/16/31	36	Very fine green sand	------	------	--------
101	36° 47′ 39″	121° 49′ 15″	6/16/31	63	Very fine green sand	0.4	0.1	--------
102	36° 47′ 32″	121° 49′ 32″	6/16/31	115	Very fine green sand	1.0	x	--------
103	36° 48′ 20″	121° 51′ 12″	6/16/31	145	Green silt	------	------	--------
104	36° 47′ 57″	121° 51′ 40″	6/16/31	167	Green silt	0.3	0.3	--------

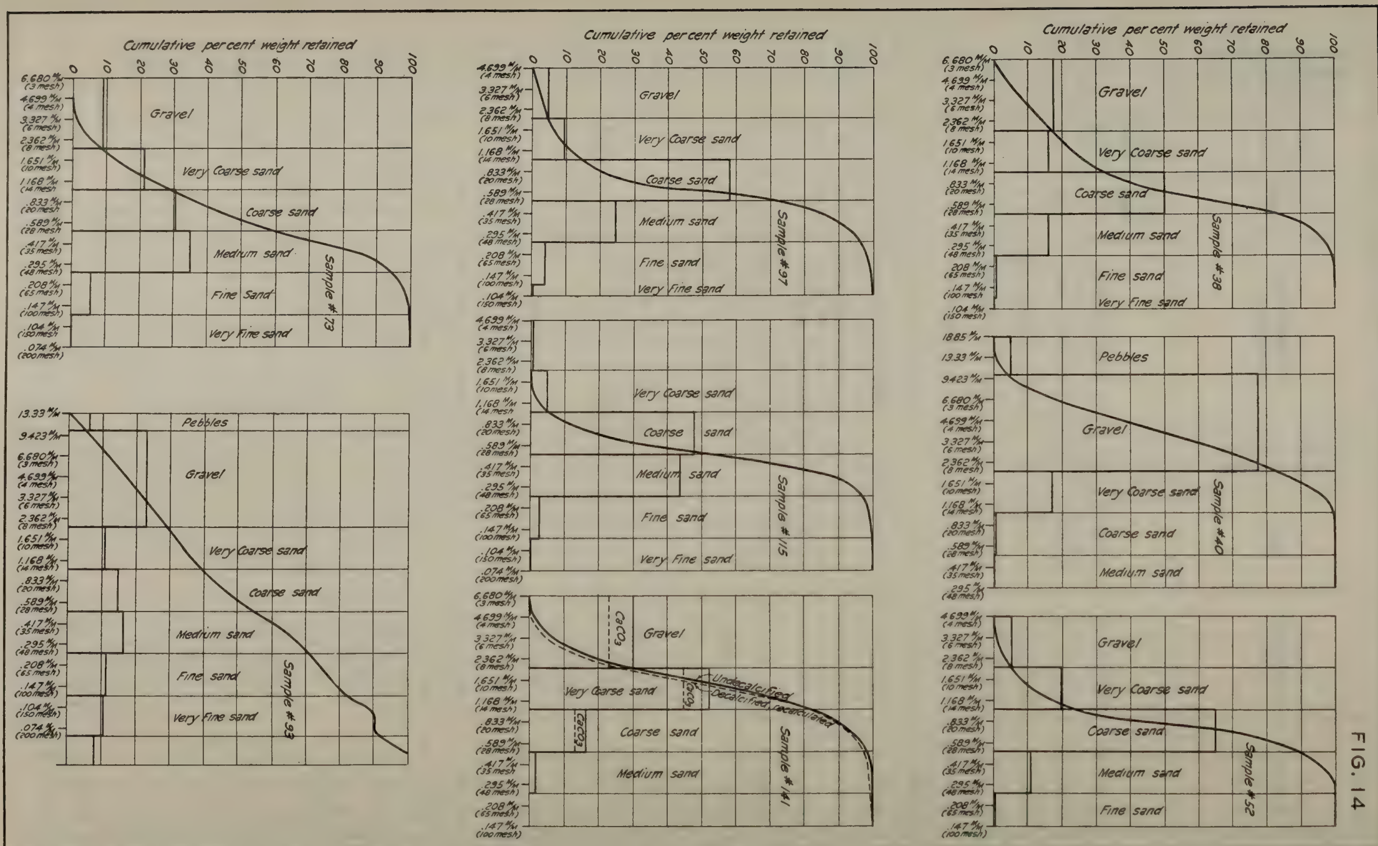


FIG. 14. Screen analyses of samples 38, 40, 52, 97, 115, 141, 73, 93. Sample No. 141 is shown both before and after treatment with acid to remove calcareous matter. Comparison of the two curves shows that the calcareous matter is practically equally distributed among the different grade sizes. Sample No. 93 is similar to No. 100 (Fig. 13) in showing wide variation in particle size.

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
105	36° 42′ 22″	121° 48′ 48″	6/18/31	7	Fine gray sand	1.5	x	12
106	36° 45′ 57″	121° 48′ 33″	6/18/31	7	Very fine gray sand	2.0	x	12
107	36° 45′ 21″	121° 51′ 45″	6/18/31	35	Green silt	0.7	0.2	16
108	36° 47′ 04″	121° 50′ 20″	6/18/31	52	Green silt	------	------	--------
109	36° 48′ 36″	121° 48′ 30″	6/25/31	25	Fine green sand and gravel	8.0	------	13
110	36° 49′ 39″	121° 50′ 00″	6/25/31	30	Very fine green sand	1.2	x	--------
111	36° 50′ 46″	121° 52′ 04″	6/25/31	30	Very fine green sand	0.4	x	--------
112	36° 52′ 51″	121° 55′ 26″	6/25/31	24	Very fine green sand	------	------	--------
113	36° 54′ 22″	121° 57′ 52″	6/25/31	21	Very fine green sand	0.4	x	13
114	36° 55′ 20″	121° 58′ 28″	6/25/31	15	Very fine green sand	------	------	13
115	36° 57′ 12″	121° 59′ 34″	6/26/31	5	Coarse sand	3.0	x	14
116	36° 53′ 14″	121° 59′ 27″	6/26/31	24	Very fine green sand	------	------	--------
117	36° 51′ 00″	121° 59′ 28″	6/26/31	46	Glauconitic green silt	0.9	0.4	--------
118	36° 49′ 06″	121° 59′ 48″	6/26/31	262	Green silt	0.6	------	16
119	36° 46′ 48″	121° 00′ 00″	6/26/31	440	Sand[1] overlying green silt	------	0.5	--------
120	36° 45′ 34″	121° 56′ 46″	6/26/31	90	Gravelly silt	------	------	16
121	36° 46′ 06″	121° 56′ 50″	6/26/31	250	Medium sand[2] overlying gray silt	0.5	x	16
122	36° 51′ 48″	121° 51′ 26″	6/26/31	14	Very fine green sand	------	------	13
123	36° 54′ 42″	121° 52′ 09″	6/26/31	8	Very fine green sand	0.3	x	13
124	36° 56′ 33′	121° 54′ 08″	6/26/31	9	Very fine green sand	------	------	13
125	36° 57′ 48″	121° 55′ 50″	6/26/31	7	Very fine green sand	2.6	------	13
126	36° 56′ 15″	121° 58′ 03″	6/26/31	8	Very fine green sand	1.6	------	13
127	36° 50′ 58″	121° 57 43″	6/27/31	107	Green silt,[3] coarser near top of core	------	------	--------
128	36° 48′ 20″	121° 56′ 01″	6/27/31	60	Glauconitic green silt	0.6	0.5	17
129	36° 46′ 20″	121° 54′ 35″	6/27/31	308	Green silt	0.3	x	--------
130	36° 37′ 46″	121° 55′ 00″	7/ 7/31	8	Fine green sand	10.0	x	13
131	36° 42′ 34″	121° 59′ 34″	7/ 7/31	269	Sand and gravel[4] overlying gray silt	------	------	--------

6—92845

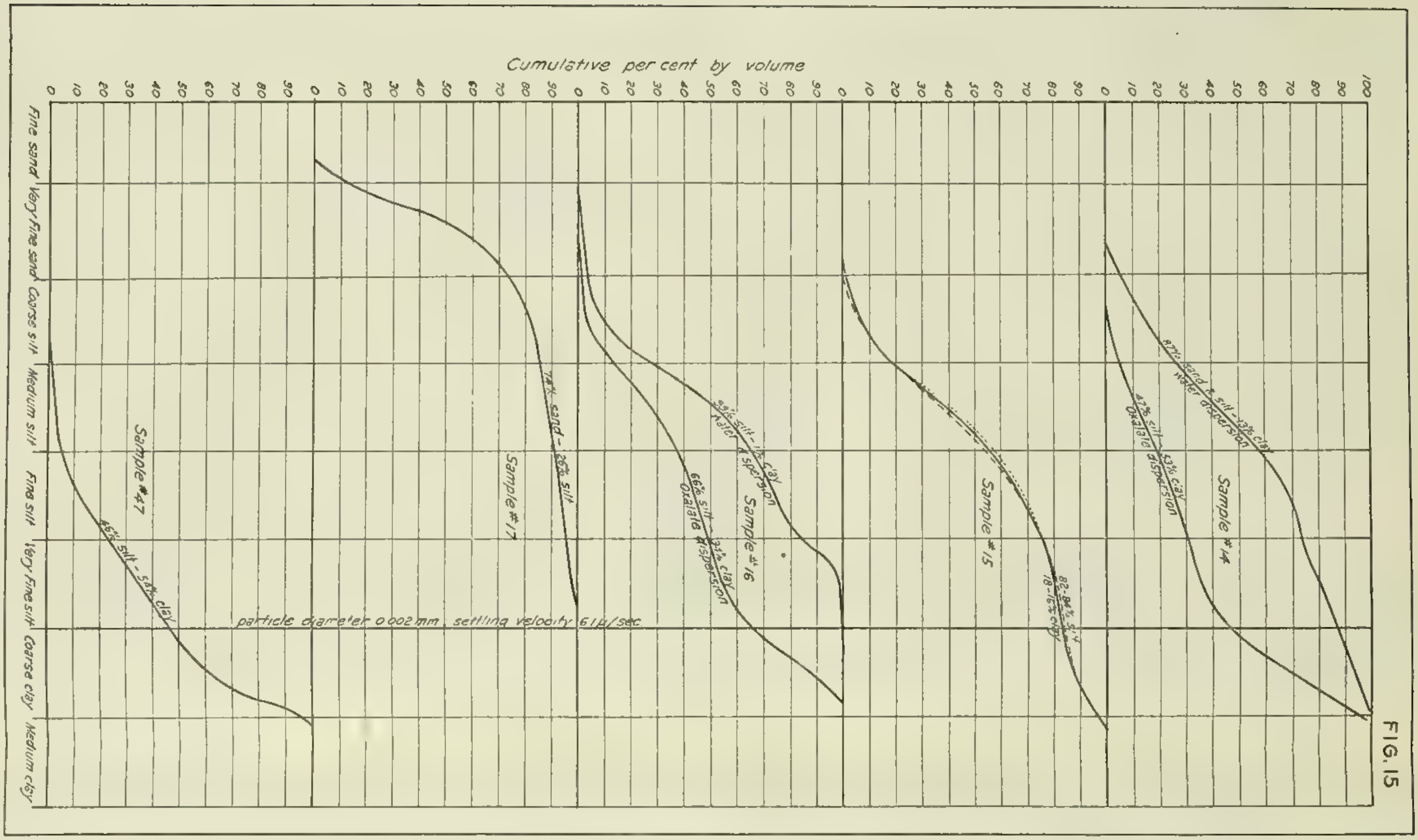


FIG. 15. 'Sedimentation' analyses of samples 14, 15, 16, 17, and 47. The velocity at which a particle fails is a function of its size. Thus, settling velocities may be used to determine the amount of particles of different sizes in a fine-grained sediment. On the vertical axes of these graphs are plotted the various fractions with fineness increasing to the right. The average limiting dimensions of the fractions are as follows:

Fine sand	0.12 mm Diameter
Very fine sand	0.07 mm Diameter
Coarse silt	0.033 mm Diameter
Medium silt	0.01 mm Diameter
Fine silt	0.005 mm Diameter
Very fine silt	0.002 mm Diameter
Clay and colloids	less than 0.002 mm.

The settling velocities of the fractions bear the constant ratio to each other of 6 : 1. From the data given for the particle diameter of 0.002 mm with a settling velocity of 6.1 microns per second, the sizes and settling velocities of the other fractions may be calculated by Stokes' law. Samples 14 and 17 show the variation which is obtained when oxalate solution (0.5N) is used in place of distilled water for dispersing the various particles into their true units. Sample 15 shows the variation which may be expected (2%) in triplicate 'runs' on the same sample.

TABULATED DREDGING DATA, SEDIMENTS OF MONTEREY BAY

Station	Latitude N.	Longitude W.	Date	Depth in fathoms (1 fathom=6 ft.)	Character of sediment	$CaCO_3$	P_2O_5	Figure number where mechanical analysis is given
						Per cent	Per cent	
132	36° 45′ 00″	121° 58′ 18″	7/ 7/31	153	Gravelly silt	0.4	x	--------
133	36° 47′ 03″	121° 57′ 53″	7/ 7/31	257	Gray silt,[5] coarser near top of core	0.7	------	17
134	36° 45′ 42″	121° 52′ 44″	7/ 7/31	152	Gray sandy silt	0.3	x	--------
135	36° 45′ 42″	121° 53′ 09″	7/ 7/31	51	Gravelly silt	------	------	--------
136	36° 49′ 38″	121° 53′ 42″	7/ 7/31	44	Green silt	0.3	x	--------
137	36° 53′ 46″	121° 54′ 15″	7/ 7/31	14	Very fine green sand	0.5	0.4	13
138	36° 52′ 06″	121° 57′ 09″	7/ 8/31	41	Fine sand[6] overlying green silt	------	------	17
139	36° 50′ 24″	121° 55′ 35″	7/ 8/31	41	Green silt	0.6	0.3	--------
140	36° 38′ 21″	121° 57′ 34″	7/ 8/31	33	Boulders	------	------	--------
141	36° 36′ 36″	121° 58′ 24″	7/ 8/31	21	Very coarse sand and gravel	17.0	x	14
142	36° 35′ 12″	121° 59′ 20″	7/ 8/31	28	Shell gravel	92.0	x	--------
143	36° 37′ 40″	121° 59′ 22″	7/ 8/31	38	Rock bottom	------	------	--------
144	36° 39′ 15″	121° 57′ 57″	8/25/31	47	Rock bottom	------	------	--------
145	36° 40′ 03″	121° 59′ 21″	8/25/31	56	Sandstone of Pliocene (?) age	------	------	--------
146	36° 48′ 26″	121° 58′ 52″	9/ 2/31	89	Silty gravel	x	x	--------
147	36° 50′ 15″	121° 56′ 33″	9/ 2/31	45	Green silt	0.4	x	--------
148	36° 36′ 48″	121° 56′ 20″	9/ 5/31	------	White sand, lee side of dune	------	------	--------
149	36° 36′ 34″	121° 56′ 57″	9/ 5/31	------	White sand	------	------	--------
150	36° 35′ 15″	121° 57′ 50″	9/ 5/31	------	White sand	------	------	--------
151	36° 35′ 00″	121° 58′ 06″	12/12/31	------	Coarse white sand	------	------	13
152	36° 37′ 00″	121° 56′ 18″	12/12/31	------	Medium white sand, dune deposit	------	------	13

(x) Indicates less than 0.1 per cent.
*Tide line; zero depth.
[1] 5 cm. layer medium sand overlying 9 cm. silt. Upper 5 cm. brown; bluish-gray below.
[2] 9 cm. layer of silty gravel overlies 4 cm. of gray silt. No sulfide layer present.
[3] Fine sand in upper 2 cm. of core grades into silt and clay in lower 5 cm.
[4] 5 cm. of silty fine-gravel overlying silt contact gradational.
[5] 3 cm. fine sand overlying 12 cm. gray silt.
[6] 5 cm. fine sand overlying gray silt.

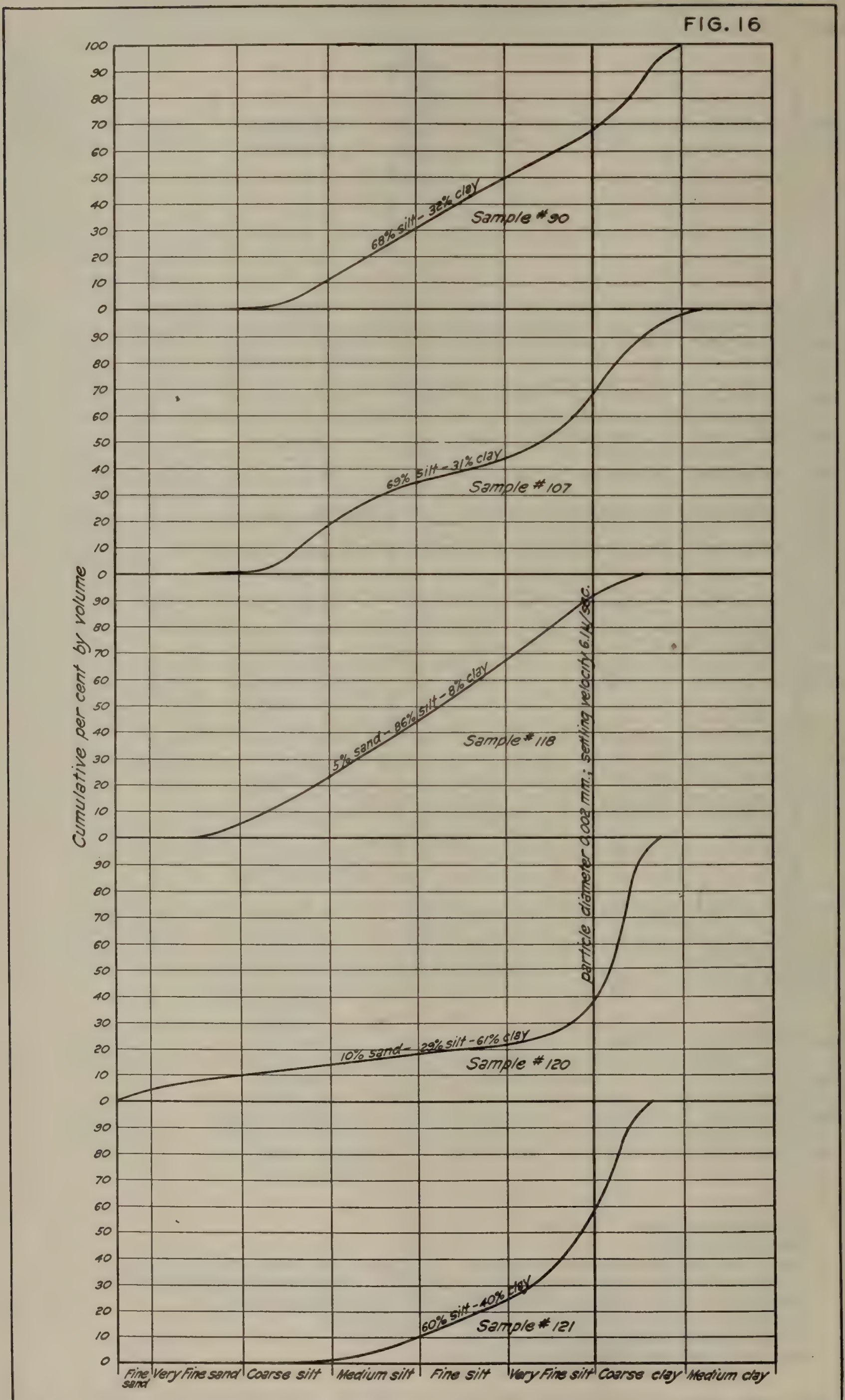


FIG. 16. 'Sedimentation' analyses of samples 90, 107, 118, 120, and 121. The explanation of Fig. 15 applies here also.

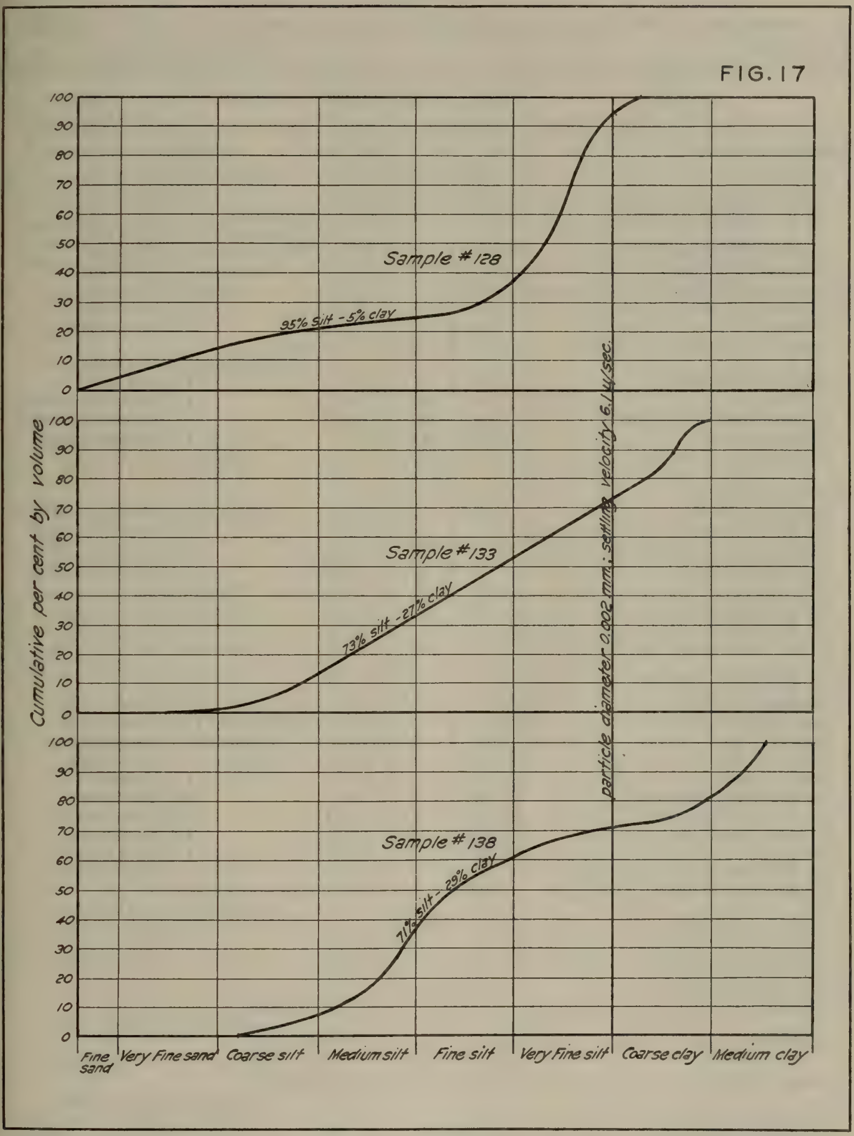


FIG. 17. 'Sedimentation' analyses of samples 128, 133, 138. The description given for Fig. 15 applies here also.

OIL FIELD DEVELOPMENT OPERATIONS

R. D. Bush, State Oil and Gas Supervisor.

From October 4, 1931, to and including January 2, 1932, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
KERN COUNTY:					
Standard Oil Co.	36	30	24	Tupman 46	Elk Hills
F. S. Jasper	23	29	27	1	Fruitvale
Ed. F. Jorgensen	23	29	27	Jorgensen-Camenish 1	Fruitvale
Mohawk Petroleum Co.	21	29	27	McDermott 1	Fruitvale
Plymouth Oil Co.	23	29	27	Fruitvale 1	Fruitvale
Seahawk Petroleum Co., Ltd.	23	29	27	B 1	Fruitvale
Treasure Oil Syn.	23	29	27	1	Fruitvale
Welport Oil Co.	26	29	21	8	McKittrick
Republic Petroleum Co., Ltd.	8	32	23	Hale-McLeod 25-A	Midway
Simms and Goldman	22	32	23	1	Midway
C. C. M. O. Co.	6	28	29	4	Round Mountain
Golden Bear Oil Co., Ltd.	6	28	29	7	Round Mountain
Barnsdall Oil Co.	15	11	20	K. C. L. 1	Wheeler Bridge
Rio Grande Oil Co.	12	27	18	Dunn 1	----------
KINGS COUNTY:					
Associated Oil Co.	35	21	17	Whepley 3	Kettleman Hills
Kettleman North Dome Association	1	22	17	21	Kettleman Hills
Kettleman North Dome Association	2	22	17	61	Kettleman Hills
Standard Oil Co.	23	22	18	25	Kettleman Hills
E. B. Guess	12	23	22	Guess 2	----------
Irma Investment Corp., Ltd.	7	23	20	Watson 2	----------
W. Byron Neil	32	22	20	1	----------
Valley Exploration Co., Ltd.	18	23	20	Veco 5-18	----------
LOS ANGELES COUNTY:					
Standard Oil Co.	13	3	11	Emery 50	Coyote Hills
Associated Oil Co.	34	3	13	De Francis 11	Dominguez
Shell Oil Co.	33	3	13	Reyes 41	Dominguez
Union Oil Co.	33	3	13	Hellman 17	Dominguez
Baldwin Hills Syn.	17	2	14	1	Inglewood
Lawndale Pioneers, Inc.	20	3	14	9	Lawndale
B. & C. Oil Co., Ltd.	19	4	12	1	Long Beach
F. E. G. Berry and Associates	20	4	12	1	Long Beach
Oscar L. Willett	20	4	12	1	Long Beach
R. W. Wardell & L. J. Menichini	7	2	11	1	Montebello
Continental Oil Co.	10	5	12	McGrath & Selover 26	Seal Beach
Davidson Oil Co., Ltd.	32	1	12	1	----------
Mohawk Petroleum Co.	29	3	14	1	----------
ORANGE COUNTY:					
Standard Oil Co.	18	3	10	Murphy-Coyote 108	Coyote Hills
Standard Oil Co.	18	3	10	Murphy-Coyote 110	Coyote Hills
Standard Oil Co.	19	3	10	Murphy-Coyote 109	Coyote Hills
Huntington Signal Oil Co.	2	6	11	Hand 2	Huntington Beach
Vaqueros Major Oil Co., Ltd.	32	5	11	1-A	Huntington Beach
SAN DIEGO COUNTY:					
Borderland Exploration Co., Inc.	Pueblo	Lot	258	City of San Diego 2	----------
SAN JOAQUIN COUNTY:					
Union Oil Co.	14	3	6	Tracy Land 1	----------

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
SAN LUIS OBISPO COUNTY:					
Emerich Oil Corp., Ltd.	--	28	12	1	----------
SANTA BARBARA COUNTY:					
Cliff Petroleum Corp.	28	4	27	28	Mesa
TULARE COUNTY:					
Gravity Exploration Co.	11	24	23	Hudson-Buck 1	----------
Kingsburg Exploration Co.	29	16	23	1	----------
VENTURA COUNTY:					
Arthur N. Macrate	32	4	18	Torrey 1	Piru
Associated Oil Co.	26	3	23	Lloyd 90	Ventura
Shell Oil Co.	29	3	23	Taylor 72	Ventura
Simi Oil Co., Ltd.	18	1	17	Hearst 2	----------

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of MINING IN CALIFORNIA.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

SANBORNITE, A NEWLY DESCRIBED MINERAL FROM CALIFORNIA

By WALTER W. BRADLEY, State Mineralogist

Sanbornite is a white to colorless, translucent silicate of barium, and was found associated with the rose-red, gillespite, and a couple of other white to colorless minerals. Late in 1930, there was sent to the laboratory of the State Division of Mines, for identification, a mineral sample from a locality apparently near El Portal, Mariposa County, where are certain commercially productive barite mines. These mines yield both the sulphate (barite) and the carbonate (witherite) of barium.

A portion of the specimen was referred to Dr. Austin F. Rogers, professor of mineralogy at Stanford University, who proved by optical tests and quantitative analyses that one of the translucent minerals is a new species, a simple barium silicate, with chemical formula, $BaSi_2O_5$.

Subsequent inquiries addressed to Mr. F. Marsh, Incline, P. O., the original sender, for more material and further data as to the exact locality, were returned unclaimed by the post office, he having meantime moved to parts unknown. So, for the present, the exact locality is not known to us,[1] but it is probably not far from El Portal because of the presence there of commercial bodies of barite, as above noted.

Not the least interesting circumstance is the association with sanbornite of the rare species, gillespite[2] ($BaFeSi_4O_{10}$), a rose-red, barium-iron silicate, found thus far previously only as a float mineral

[1] Since the above was written, the deposit has been identified by Mr. John Melhase, geologist, San Francisco, and Mr. Marsh, the original discoverer, has returned. Some excellent museum specimens have been obtained and are now on display.—W. W. B.

[2] Schaller, W. T., Gillespite, a new mineral: Jour. Wash. Acad. Sci., Vol. 12, p. 7, 1922.

Ibid. The properties and associated minerals of gillespite: Amer. Mineralogist, Vol. 14, pp. 319–322, 1929.

on a glacier in Alaska, and celsian ($BaAl_2Si_2O_8$), the barium feldspar, identified originally from Jakobsberg, Sweden. There are also at least two other as yet unnamed minerals associated. Dr. Rogers first made known his findings at a meeting of the Le Conte Club at the University of California in Berkeley on December 5, 1931, and later (Dec. 30, 1931) presented a paper in more detail at the meeting of the Mineralogical Society of America at Tulsa, Oklahoma. Mr. Frank Sanborn, thus honored by the naming of this new mineral for him, has been mineral technologist of the State Division of Mines since September, 1920; and has been a particularly conscientious, careful, and thorough worker in his chosen line. We are pleased to see his interest and efforts thus recognized.

Dr. Rogers has furnished us with the following notes relative to the new mineral and its associates.

SANBORNITE, A NEW BARIUM DISILICATE MINERAL FROM MARIPOSA COUNTY, CALIFORNIA

By Austin F. Rogers

Sanbornite is the first simple barium silicate mineral ever found. So far as known, it probably has no commercial value. It brings up to apparently 39 in number, the mineral species first described from Californian localities, making California nip-and-tuck with New Jersey (on account of the prolific Franklin Furnace district) in the race for first place among the states. These Californian minerals with their dates of identification are:

Calaverite, 1868.
Melonite, 1868.
Metacinnabar, 1870.
Priceite, 1873.
Tincalconite, 1878.
Colemanite, 1883.
*Hanksite, 1884.
*Sulphohalite, 1888.
*Knoxvillite, 1890.
Iddingsite, 1893.
Lawsonite, 1895.
*Northupite, 1895.
*Pirssonite, 1896.
*Bakerite, 1903.
*Boothite, 1903.
*Tychite, 1905.
*Benitoite, 1907.
*Joaquinite, 1909.
*Palaite, 1912.
*Sicklerite, 1912.
*Salmonsite, 1912.
*Stewartite, 1912.
*Wilkeite, 1914.
*Inyoite, 1914.
*Meyerhofferite, 1914.
Searlesite, 1914.
*Crestmoreite, 1917.
*Riversideite, 1917.
*Plazolite, 1920.
*Vonsenite, 1920.
*Jurupaite, 1921.
Merwinite, 1921.
*Kempite, 1924.
*Foshagite, 1925.
*Kernite, 1927.
*Probertite, 1929.
*Scharirerite, 1931.
*Krausite, 1931.
*Sanbornite, 1931.

Most of the above species are of mineralogic interest only, having little or no known commercial value; but exception may be noted of the following: calaverite, gold telluride; metacinnabar, black sulphide of mercury (quicksilver); colemanite, hydrous calcium borate; benitoite, barium titano-silicate, a blue gem; kernite, hydrous sodium borate.

(Abstract) [1]

Sanbornite is a triclinic mineral with perfect cleavage parallel to (001) and polysynthetic twinning parallel to (010). The indices of refraction are $n\gamma=1.624$, $n\beta=1.616$, and $n\alpha=1.597$, all $\pm.001$. It is optically negative with $2V=66°$ (calculated from the indices). The optical orientation is γ nearly normal to (001) and the axial plane nearly normal to (010). The chemical formula is $BaSi_2O_5$. A probable structure with $Ba_2Si_4O_{10}$ as the unit is given. It occurs in what is probably a contact metamorphic deposit (exact locality is unknown) associated with quartz, diopside, gillespite, tourmaline, pyrrhotite, celsian (first reported occurrence in the United States), and several unknown minerals.

* So far as known, the starred minerals have not yet been found outside of the State of California.

[1] Abstract of paper presented at Tulsa, Okla., Dec. 30, 1931; to be printed in American Mineralogist, March, 1932.

TOPOGRAPHIC MAPPING PROGRAM FOR CALIFORNIA [a]

By Everett N. Bryan [b]

A definite program of topographic mapping in California has been agreed upon by the district office of the U. S. Geological Survey and the State Engineer's office having as its object the completion of a reasonably satisfactory topographic base map of the State of California.

The Federal government, through the local office of the U. S. Geological Survey, and the State of California, through the office of State Engineer, are carrying on this work on a dollar for dollar cooperative basis and the program arranged is the culmination of some five months effort beginning with a conference on May 8, 1931, to which all major agencies concerned with the production and use of these maps were invited to send representatives.

The U. S. Geological Survey, the State Engineer's office, the State Division of Highways, the Corps of Engineers U. S. Army, the California Forest Experiment Station, the California Economic Research Council, the State Division of Mines, the U. S. Forest Service and the College of Agriculture of the University of California were all represented by personal appearance at this conference and several other agencies made appearance by letter.

The program arranged provides for the mapping of all previously unmapped areas. the remapping of all areas for which there are presently available only the U. S. Army tactical maps, the resurvey of all areas for which there are presently available only U. S. Geological Survey topographic maps of a scale of 1:250,000 surveyed prior to 1890, the completion of surveys made by the city of Los Angeles in San Bernardino, Riverside and Imperial counties, the resurvey of certain mining, recreational and forested areas in the northern Sierra done some 40 years ago, and the resurvey of highly developed areas in western San Bernardino and Riverside counties and in San Diego County wherein there have been many cultural changes and there are presently available only small scale maps done 30 to 35 years ago. Completion of the program involves the mapping of some 75,000 square miles or 47 per cent of the area of the State and it is estimated will cost $1,660,000. On the basis of expenditures proposed during the current year it will require fourteen years, or until 1945 to complete the program.

Areas Scheduled.

The more important general areas which are scheduled for mapping proceeding from north to south include the following:

1. The north coastal area for which there are now available only the U. S. Army tactical maps, which are wholly inadequate for general purposes.

2. The extreme northern and northeastern portions of California for which there are now available only the old U. S. Geological survey quadrangle sheets of a scale 1:250,000 done prior to 1890.

[a] Reprinted from California Highways and Public Works, November, 1931.
[b] Hydraulic Engineer, Division of Water Resources.

3. Previously unsurveyed or only partially surveyed areas in the Clear Lake to Redding Coast Range section, for which there are now no published maps available.

4. Recreational, mining and forested areas in the northern Sierra from Quincy south to Yosemite, for which there are presently available only U. S. Geological Survey Quadrangles, done some 35 to 47 years ago.

5. Unmapped areas on southern San Joaquin Valley floor.

6. Areas in San Bernardino, Riverside, Orange and Imperial counties, for which there are now either no published maps or only those done 30 to 35 years ago.

Arrangement of the program required a determination of two very important factors—the scales which should be used and the order in which the work should be undertaken. While it was readily agreed that no new work should be done on the scale 1:250,000 (i. e., 4 miles to the inch) there was considerable room for choice between the larger scales and an earnest desire was manifested among the various users of the maps for large scale work.

There is, however, a very rapid increase in cost with an increase in scale and if the program of mapping was to be completed in reasonable time with the funds which would probably be made available it was necessary to make some sacrifice on this point. In this connection the following comparative estimates of cost are of interest:

Field scale		*Published scale*	*Cost per sq. mile*
1:192,000	1:250,000	(4 mi. to 1 inch)	\$10.00 to \$15.00
1:96,000	1:125,000	(2 mi. to 1 inch)	\$15.00 to \$25.00
1:48,000	1:62,500	(1 mi. to 1 inch)	\$40.00 to \$60.00
1:31,680	1:31,680	(½ mi. to 1 inch)	\$50.00 to \$80.00

While the scale agreed upon in a few cases are not as large as desired by some of the users it will be noted that fourteen years are required to complete the program even with the smaller scales adopted.

Division of Work.

In the matter of order of mapping there was also some difficulty in arriving at a schedule which would be generally satisfactory. Each area and interest, impressed with the seriousness of its own need, would, if given its choice, place its own work first. It is manifestly unfair and impracticable, however, to confine all work for a great length of time to one section of the State.

In order to secure maximum efficiency in field work it is necessary to divide the work fairly equally between the northern and southern portions of the State, confining the winter work to southern California. It has appeared equitable and proper also to distribute the annual expenditures among the various interests such as agriculture, mining, forestry, recreation, etc. In the program of mapping agreed upon, therefore, the schedule of annual expenditures is divided fairly equally between the various geographical areas and interests.

The possibilities of expediting completion of this program by adoption of aerial methods in place of the ordinary ground surveys will not be overlooked. An area which will afford a reasonable test both in the matter of cover and slope has been selected in the vicinity of Clear Lake and it is expected that within the next few months aerial mapping

will be given a test by which it will be possible to compare the new method with the old in matter of both cost and accuracy.

Revision Experiment.

Another experiment which will be tried as soon as weather conditions will permit and the work can be organized is that in connection with a cultural revision of some of the older quadrangles. In the vicinity of Lake Tahoe where there has been a very marked recreational development in recent years the only topographic sheets available are those surveyed more than 40 years ago. These are published on the 1:125,000 scale and it is believed the topography is sufficiently accurate that they can be made to serve present purposes reasonably well if the culture is revised to show the new roads, trails, settlements, etc. The Truckee sheet has been selected for this test and it is hoped to work out some method by which all adjoining sheets may be redone at reasonable cost.

In San Bernardino, Riverside and Imperial counties some 15,000 square miles have in recent years been surveyed by the city of Los Angeles in connection with its investigation of the Colorado River project. These surveys have not been published but blue print maps thereof are available on a scale of 1:125,000, lacking however, the land lines and some of the other detail of the U. S. G. S. topographic sheets. It is expected to complete these surveys and publish the maps.

Experimentation will start within the year on the Hinkley quadrangle in the vicinity of Barstow in an effort to work out the best method and determine the cost.

As a necessary preliminary to proposed topographic mapping datum points must be established for elevation and for position. These datum points are permanent marks of which a list and descriptions may be obtained from the Geological Survey and they therefore are invaluable to California engineers. Local surveys for highways, canals, dams and reservoir sites and all other engineering projects can be referred to these permanent marks thus making each such survey in the State a part of an homogeneous whole.

TARIFF RATE CHANGED ON FELDSPAR

After recommendation by the Tariff Commission, President Hoover, under the flexible provisions of the tariff law, on December 2, 1931, made seven changes in the tariff structure, raising two duties and lowering five. The only change affecting crude mineral products was the lowering of the duty on crude feldspar from $1 to 50 cents per ton.

The duty on window glass was reduced by 25 per cent.

Other commodities studied by the commission were cement and ground feldspar, but it was recommended that present levies on them be continued.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

Mr. Amiel H. Brod, who had been laboratory assistant under this Division and its predecessor the State Mining Bureau since August, 1913, passed away on December 4, 1931, following an illness of over a month. His was a long and interested service, always cheerfully given, always doing for others.

Mr. Frank Sanborn, mineral technologist of the Division of Mines has been honored by having had named for him a new mineral found recently in Mariposa County of this State. The story of this new mineral and its identification is given elsewhere herein under 'Special Articles.'

New Publications.

Mining in California (quarterly), July, 1931, being Chapter 3, of the State Mineralogist's Report XXVII. Price 25 cents. Contains: "Mines and Mineral Resources of Yuba and San Bernardino counties;" "Feldspar, Silica, Andalusite, and Cyanite Deposits of California;" "A Note on a Deposit of Andalusite in Mono County, California: Its occurrence and Technical Importance;" "Establishment of Trinity and Klamath River Fish and Game District Affects Mining;" "U. S. Mint Aids Prospectors."

Commercial Mineral Notes, Nos. 103, 104, 105, October, November, December, 1931, respectively. These 'notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet, monthly. It is mailed free to those on the mailing list for MINING IN CALIFORNIA. As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded to two pages for the current issues.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

California's Mineral Production in 1931.

The total value of the mineral production of California for the year 1931, just closed, is conservatively estimated by the statistical division to have been $220,290,000. This is, in part, detailed in the tabulation below, but as there are more than fifty mineral substances on California's commercial list, it is impracticable at this early date to obtain definite figures on other than the more important items. The blank report forms are being mailed to the operators in all mineral lines, and the detailed and complete report will be compiled and published later.

The estimated total of $220,290,000 is a decrease of approximately $145,314,000 from the value of 1930 production. Gold is the only major mineral substance whose output showed an increased value over the previous year. Petroleum registered the largest decrease, with lesser decreases shown by cement, natural gas, metals, structural materials, industrial materials and salines. The value of the crude oil output was approximately 46% less with a decrease of about 39,000,000 barrels in quantity from 1930. Prices during the year were much lower. On March 30th there was a reduction in crude oil prices of all grades, crude oil heavier than 20° B being quoted at 55c–65c a barrel, while that of 30° B and lighter brought 35c. This was the first time in the history of California oil fields that the heavier crudes were worth more than the lighter. This condition lasted until June 19th when the prices on light crudes were increased slightly over those of the heavier. Around 85% of the crude oil at present produced in California is above 20° B, some testing as high as 60° B, while the low grade ranges down to 9° B.

Receipts of bullion at the mint and smelters show an increase in the gold yield of about $1,250,000 compared with 1930, this being due to increased production in the principal lode mines, and the large number of small placer operators due to the unemployment in other industries. The output from the dredges showed little change. Silver and copper showed large decreases in both quantity and value, while lead showed an increased quantity with a decreased value. The quicksilver output was approximately the same, but having a decreased value.

The structural group shows a decrease of about 35% as did building permits in 53 California cities. Both the industrial and saline groups show likewise large decreases in value.

The estimated values and quantities for 1931 are as follows:

$10,708,000	gold
242,000	(836,000 fine oz.) silver
1,099,000	(13,250,000 lbs.) copper
142,000	(3,750,000 lbs.) lead
961,000	(11,000 flasks) quicksilver
75,000	other metals, including manganese
146,873,000	(188,268,000 bbls.) petroleum
20,350,000	(313,120,000 M cu. ft.) natural gas
9,100,000	(7,000,000 bbls.) cement
13,140,000	crushed rock, sand and gravel
3,000,000	brick and hollow building tile
300,000	(30,000 tons) magnesite
1,000,000	other structural materials, including granite, lime, etc.
5,500,000	miscellaneous industrial materials
7,800,000	salines, including borates, potash, salt, soda, etc.
$220,290,000	

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America; and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

Frank Sanborn, Mineral Technologist

The laboratory of the Division of Mines is maintained for the purpose of identifying minerals and making qualitative analyses of rocks. These determinations and analyses are made without cost to those who seek the services of this State department. Ordinarily, a small sample weighing not over half a pound, in the lump form if possible, should be submitted with a letter stating what particular tests are desired, if there is a special reason for sending the material. Not more than three samples should be sent at one time, nor is it necessary to send more than one. Information regarding the size of the deposit and its proximity to rail transportation is useful in determining the possible value of a mineral body.

When requested, assistance in finding a market for a mineral will be given. When such help is desired, a small representative sample of the material for which a market is sought should accompany the request. The Division is occasionally able to send a very small sample of a particular mineral for comparative purposes to any earnest prospector. Very small pieces of certain silicates, such as andalusite, have been supplied to those desiring them.

Several thousand determinations are made annually by the Division of Mines, and prospecting and exploitation of the state's mineral wealth increases as the State becomes more thickly populated. Each year new occurrences of some mineral in the State are reported, and occasionally a new mineral species is found. New uses for a mineral are frequently found, and as a result stimulus is given to searching for that particular substance.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of Federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICAL PUBLICATIONS RECEIVED

Governmental.

U. S. Geological Survey:

Bulletins:

824–B—The Slano District, Upper Copper River Region, Alaska. By F. H. Moffit.

824–C—The Lake Clark-Mulchatna Region, Alaska. By S. R. Capps.

824–D—Mining in the Circle District, Alaska. By J. B. Mertie, Jr.

824–E—The Occurrence of Gypsum at Iyoukeen Cave, Chichagof Island, Alaska. By B. D. Stewart.

828 —Geology and Mineral Resources of the Quakertown-Doyleston District, Pennsylvania and New Jersey. By E. Bascom, E. T. Wherry, G. W. Stose and A. I. Jonas.

Annual Report of the Director of the Geological Survey.

836–A—Mineral Industry of Alaska in 1930 and Administrative Report. By P. S. Smith.

836–B—Notes on the Geography and Geology of Lituya Bay, Alaska. By J. B. Mertie, Jr.

Professional Papers:

164 —The Kaiparowits Region. A Geographic and Geologic Reconnaissance of Parts of Utah and Arizona. By H. E. Gregory and R. C. Moore.

165 —Shorter Contributions to General Geology, 1930.
168 —Origin and Microfossils of the Oil Shale of the Green River Formation of Colorado and Utah. By W. H. Bradley.
170–A—Claciation in Alaska. By S. R. Capps.
170–C—A Miocene Flora From Grand Coulee, Washington. By E. W. Berry.

Water-Supply Papers:
663 —Part III. Ohio River Basin.
681 —Part I. North Atlantic Slope Drainage Basins.
684 —Part IV. St. Lawrence River Basin.
687 —Part VII. Lower Mississippi River Basin.
689 —Part IX. Colorado River Basin.
693 —Part XII. North Pacific Slope Drainage Basins.
705 —Part X. The Great Basin.

U. S. Bureau of Mines:

Bulletins:
337 —Jigging, Classification, Tabling and Flotation Tests of Coals Presenting Difficult Washing Problems, with Particular Reference to Coals from Pierce County, Washington. By B. M. Bird and S. M. Marshall.
343 —Permissible Coal-Handling Equipment. By Isley; Gleim & Brunot. National Survey of Fuel Oil Distribution, 1930.
344 —Methods and Apparatus Used in Determining the Gas, Coke, and By-Products Making Properties of American Coal.
347 —Gases That Occur in Metal Mines. By D. Harrington & E. H. Denny.

Technical Papers:
502 —How to Compute Tables for Determining Electrical Resistivity of Underlying Bids and Their Application to Geophysical Problems. By I. Roman.
504 —Engineering Report of Cotton Valley Field, Webster Parish, La. By J. S. Ross.
505 —Influence of Fractionation on Distribution of Sulphur in Gasoline. By R. H. Espach & H. P. Rue.
507 —Explosions in Washington Coal Mines. By S. H. Ash.
513 —Studies on Determination of Sulphur in Gasoline. By R. H. Espach and O. C. Blade.

Monographs:
4 —Warning Agents for Fuel Gases.

Mineral Resources of the United States:
Arsenic, Bismuth, Silenium and Tellurium in 1930.
Coke and By-Products in 1929.
Gold and Silver in 1929.
Gold, Silver, Copper, Lead and Zinc in Colorado in 1929.
Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1930.
Graphite in 1930.
Gypsum in 1930.
Mercury in 1930.
Silica in 1930.
Sulphur and Pyrites in 1930.
Slates in 1930.
Mineral Resources of the United States, 1930, (Summary).
Abrasive Materials in 1930.
Iron Ore, Pig Iron and Steel in 1930.
Clay in 1930.
Coal in 1929.
Feldspar in 1930.
Lead and Zinc Pigments and Salts in 1930.
Magnesium and Its Compounds in 1930.
Platinum and Allied Metals in 1930.
Silver, Copper, Lead, and Zinc in the Central States in 1930.
Vanadium, Uranium and Radium in 1930.

Recent Articles on Petroleum and Allied Substances:
Monthly issues.

Report of Investigations:

3131—The Use of Aluminum For Oil Lease Tanks; Part II—Laboratory Tests. By Ludwig Schmidt, John M. Devine, and C. J. Wilhelm.
3135—An Apparatus For the Determination of Hydrogen Sulphide in Gases. By J. W. Horne and W. B. Shirey.
3143—The Production of Motor Fuels From Natural Gas. 1. Preliminary Report on the Pyrolysis of Methane. By H. M. Smith, Peter Grandone, and H. T. Rall.
3145—Survey of Fuel Consumption at Refineries in 1930.
3150—Official Changes in the Active List of Permissible Explosives and Blasting Devices for October, 1931.
3152—Twenty-third Semi-annual Motor-Gasoline Survey—Part III.
3155—Official Changes in the Active List of Permissible Explosives and Blasting Devices for November, 1931.

Information Circulars.

6496—A Comment Upon Present-Day Applied Geophysics. By F. W. Lee.
6512—Mining Methods and Costs at the Central-Eureka Mine, Amador County, Calif. By James Spiers.
6513—Method and Cost of Quarrying Limestone at the Quarry of the Trinity Portland Cement Co., Fort Worth, Tex. By William Ganser.
6516—Mining Laws of Great Britain. By E. P. Youngman.
6518—Garnets (Gem Stones). By I. Aitkens.
6519—Fatal Accidents in Alabama Coal Mines During 1930. By F. E. Cash and H. B. Humphrey.
6521—Safety in the Iron Mines of the Menominee Range, Michigan. By F. S. Crawford.
6522—Method and Cost of Quarrying, Crushing, and Grinding Limestone at the Catskill Plant of the North American Cement Corporation, Catskill, N. Y. By W. J. Fullerton and Albert W. Cox.
6526—Deep Mining Methods, Conglomerate Mine of the Calumet and Hecla Consolidated Copper Co. By Harry Vivian.
6527—Practical Rules for the Use of the Magnetometer in Geophysical Prospecting.
6529—Accident Experience, and Cost of Accidents in Washington Coal Mines.
6530—Accident Experience of the Coal Mines of Utah, for the period 1918 to 1929.
6531—Mining and Crushing Methods and Costs at the Tiffin Limestone Quarry of the Thurber Earthen Products Co., Fort Worth, Tex. By Dayton C. Bolin.
6532—Methods And Costs Of Concentrating Tungsten Ores At Atolia, San Bernardino County, Calif. By Wm. O. Vanderburg.
6533—Feldspar Gems (Amazon Stone, Moonstone, Sunstone, etc.).
6534—Mining Laws of Palestine.
6535—Mining Laws of Austria.
6536—Mining Laws of Ethiopia (Abyssinia).
6537—Mining, Treatment, Methods, and Costs at the East Texas Gravel Co.'s Deposits Near Bois D'Arc, Tex. By Walter W. Hyde.
6538—List of Permissible Mine Equipment.
6539—Tourmaline.
6540—Mine Explosions and Fires in the United States, During the Fiscal Year Ending June 30, 1931.
6541—Milling Methods and Costs of the Coniaurum Mines, (Ltd.), Schumacher, Ontario. By John Redington.
6542—Mining Laws of Latvia.
6543—Mining Practices, Methods and Costs at Elkoro Mines, Jarbidge, Nevada.
6544—Milling Methods and Costs of the Minas de Matahambre, S. A., Concentrator.
6545—The Bureau of Mines Coal Sampling Truck.
6546—Safety at the Old Dominion Copper Mine, Globe, Ariz.
6568—Geophysical Abstracts No. XXX. By Frederick W. Lee.

6575—Geophysical Abstracts No. XXXI.
6583—Geophysical Abstracts No. XXXII.

U. S. Bureau of Foreign and Domestic Commerce:
Monthly Summaries of Foreign and Domestic Commerce of the United States.

U. S. Coast and Geodetic Survey:
Annual Reports.

U. S. Treasury Department:
Annual Reports.

U. S. War Department:
Annual Reports of the Chief of Engineers, U. S. Army.

California State Board of Harbor Commissioners:
Biennial Report, 1928–1930.

California State Department of Industrial Relations:
First Biennial Report, 1927–1930.

California State Department of Public Works:
"California Highways and Public Works."

California State Division of Fish and Game:
"Conservation of Wild Life Through Education."

Connecticut State Geological and Natural History Survey:
Bulletins.

Idaho Bureau of Mines and Geology:
No. 14—Geology and Mineral Resources of Eastern Cassia County, Idaho. By A. L. Anderson.

Illinois State Geological Survey:
P. B. No. 21—The Need for Sand Coring in the Southeastern Illinois Oil Field. By A. H. Bell and R. J. Piersal.

Kentucky Geological Survey:
Volume 38, Series 6—Natural Gas in Western Kentucky.
Volume 36, Series 6—The Paleontology of Kentucky. By W. R. Jillson.
Geology of the Deep Wells in Kentucky. By W. R. Jillson.

Louisiana State Department of Conservation:
"Louisiana Conservation Review."

Nevada State Bureau of Mines and Mackay School of Mines:
Volume 25, No. 5—Ore Deposits of the Gold Circle Mining District, Elko Co., Nevada. By E. H. Rott, Jr.
Volume 25, No. 6—Bedded deposits of Manganese, Oxides Near Las Vegas, Nevada. By D. F. Hewett, and B. N. Webber.
Volume 25, No. 7—Spruce Mountain District, Elko Co., and Cherry Creek (Egan Canyon) District, White Pine Co. By F. C. Schrader.

Oklahoma Geological Survey:
Bulletin 55—The Stratigraphy and Physical Characteristics of the Simpson Group.

South Dakota Geological and Natural History Survey:
R. I. No. 2—A Preliminary Report on the Chalk of Eastern S. Dakota. By E. P. Rothrack.

Tennessee State Division of Geology:
Bull. 40—Surface Waters of Tennessee. By W. R. King.
Bull. 42—Preliminary Report on the Artesian Water Supply of Memphis, Tenn.

Texas Bureau of Economic Geology and Technology:
Mineral Resources of Bastrop, Travis, and Williamson Counties.
2901: Contributions to Geology.

2907: Ostracoda of the Cretaceous of North Texas.
2913: Stratigraphic and Structural Studies in North Central Texas.

Governmental, foreign:

Canada Department of Mines:

No. 707—Chrysotile Asbestos in Canada. By J. G. Ross.
No. 723—Investigations of Mineral Resources and the Mining Industry, 1930. (Includes article on bentonite and diatomite.)
Nos. 2292, 2289, and 2293—Summary Reports, 1930.
Memoir 165—Studies of Geophysical Methods, 1928 and 1929.

England and Wales Geological Survey:
Memoirs.

Finlande Commission Geologique:
Bulletins.

Great Britain Geological Survey:
Summaries of Progress, etc.

Imperial Geological Survey of Japan:
Explanatory Texts of the Geological Map of Japan.

New Zealand Department of Scientific and Industrial Research:
Reports.

Nova Scotia Department of Public Works and Mines:
Annual Reports.

Ontario Department of Mines:
Reports.

Scotland Geological Survey, Edinburg, Scotland:
Memoirs.

Secretaria de Industria, Comercio y Trabajo, Mexico:
Boletin Minero y del Petroleo

U. S. S. R. Geological and Prospecting Service:
Transactions.

Societies and Educational Institutions.

American Petroleum Institute:
Proceedings, Bulletins, etc.

American Journal of Science.

American Philosophical Society:
Proceedings.

American Association of Petroleum Geologists:
Bulletins.

American Geographical Society of New York:
Geographical Review.

Bulgarian Geological Society:
Reviews.

American Institute of Mining and Metallurgical Engineers:
Transactions.

Carnegie Institution of Washington.

Colorado Scientific Society.

Canadian Institute of Mining and Metallurgy:
Bulletins.

Cleveland Museum of Natural History:
Scientific Publications.

Commonwealth Club, San Francisco:
Journals.

Economic Geology.

Field Museum of Natural History:
Geological Series.

Far Eastern State University:
Publications.

Geological Society of America:
Bulletins.

Institution of Mining and Metallurgy, London:
Bulletins.

Instituto Geologica de Mexico, Mexico, D. F:
Bulletins.

Journal of Geology.
Journal of Paleontology.
Journal of Sedimentary Petrology.

Library of Congress:
Monthly Check-Lists of State Publications, Annual Report.

Mineralogical Society of America:
Journals.

Mining and Metallurgical Society of America:
Bulletins.

Museu Nacional, Rio de Janerio:
Boletim.

Nebraska State Museum:
Bulletins.

New York Academy of Science:
Annals.

Northwest Scientific Association:
"Northwest Science."

Philippine Journal of Science, Manila.

Records of the Australian Museum, Sydney, Australia.

Ryojun College of Engineering:
Memoirs.

San Diego Society of Natural History:
Memoirs: Vol. K—Catalogue of the Marine Pliocene and Pleistocene Mollusca of California and Adjacent Regions. By U. S. Grant, IV and H. R. Gale.
Transactions.

Seismos Company; Hannover, Germany:
I. Exploration of Rock Strata and Mineral Deposits by the Seismic Method.
II. On the History of the Seismic Method for the Investigation of Underground Formations and Mineral Deposits.

Shanghai Science Institute, Shanghai, China:
Bulletins.

Smithsonian Institution:
Annual Report.

Southern California Academy of Sciences:
Bulletins.

Stanford University Publications:
Abstracts of Dissertations, Geological Sciences.

Sveriges Geologiska Undersökning, Stockholm.

Tohoku Imperial University, Japan:
Science Reports.

University of California Publications, (Geological Sciences):
Vol. 21, No. 1—The Geology of Ben Lomond Mountain. By A. A. Fitch.
Nos. 2 and 3—Borophagns Littoralis from the Marine Tertiary of California. By V. L. Vander Hoof. Stratigraphy of the Borophagns Littoralis Locality, California. By W. F. Barbat and A. A. Weymouth.
Vol. 21, No. 4—Cretaceous Beds at Slate's Hot Springs, California. By J. O. Wornland and H. G. Schinck (Geography).
Vol. 5, No. 3—Prehistoric Settlements of Sonora, with Special Reference to Cerros de Trincheras. By C. Sauer and D. Brand.

Washington State College, Engineering Experiment Station:
Vol. 13, No. 10—A method of Compiling Approximate Mining Cost Data. By G. E. Ingersoll.

Washington University Studies:
Contributions in Geology.

Western Society of Engineers:
Journals.

Westpreutzischen Batanisch-Zoologischen, Vereins, Leipzig.

Books.

Heaton's Handbook, Canada, 1931.
A Handbook of Rocks. By J. F. Kemp.
The Working of Semi-Precious Stones. By J. H. Howard. (Rocks and Minerals.)
Report of California Oil Survey Committee.
Physiography of Western United States. By N. M. Fenneman.

Maps.

U. S. S. R. Geological Survey:
Geological Map of the Caucasus.

U. S. Geological Survey Topographic Sheets:
California:
Rio Bravo Quadrangle, Kern County.
Little Rock Quadrangle, Los Angeles County.
Pearland Quadrangle, Los Angeles County.
Towne Oil Station Quadrangle, Fresno County.
Edison Quadrangle, Kern County.
Mouth of Cantua Creek Quadrangle, Fresno County.
Deepwell Ranch Quadrangle, Kern County.
Wheatville Quadrangle, Fresno County.

Oklahoma:
Skedee Quadrangle.
Drumright Quadrangle.

Texas:
Terry Quadrangle.
Bend Quadrangle.
Whitney Quadrangle.
Dennis Quadrangle.
Zavalla Quadrangle.
Orla Quadrangle.
Rotan Quadrangle.
Aspermont Quadrangle, Stonewall County.
Archer City Quadrangle, Archer County.

McGregor Quadrangle.
Iola Quadrangle.
Mullins Quadrangle, Mills County.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Architect and Engineer, San Francisco.
Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Mining Journal, Nevada City.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical Engineering and Mining Review, Melbourne, Australia.
Chemical & Metallurgical Engineering, New York City.
Commerce Reports, Washington, D. C.
Colorado School of Mines, Golden, Colorado.
Cooper-Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa.
Industrial Employment Information Bulletin, Washington, D. C.
Johnson National Driller's Journal, St. Paul.
Lubrication, The Texas Co., New York City.
Mining Congress Journal, Washington, D. C.
Mining and Industrial Record, Vancouver, B. C.
Mining Journal, Phoenix, Arizona.
Mining Journal, London.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil Bulletin, Los Angeles.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Oil, Philadelphia.
Pacific Purchaser, San Francisco.
Petroleum Times, London, E. C. 2.
Petroleum World, Los Angeles.
Pit and Quarry, Chicago.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.
Union Oil Bulletin, Los Angeles.

Newspapers.

The following papers are received and kept on file in the library:

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.

Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
California Oil World, Los Angeles, California.
Colusa Daily Sun, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Sentinel, Etna Mills, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Mining World, Los Angeles.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of MINING IN CALIFORNIA was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of MINING IN CALIFORNIA, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list for MINING IN CALIFORNIA.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
**Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	----
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period 1917–1918, Fletcher Hamilton:	
Mines and Mineral Rosources of Nevada County, 270 pp., paper	.75
Mines and Mineral Resources of Plumas County, 188 pp., paper	.50
Mines and Mineral Resources of Sierra County, 144 pp., paper	.50

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	$1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, **May, **June, **July, August, September, October, **November, December, 1922	Free
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.25
April, 1925, Mines and Mineral Resources of Calaveras. Merced, San Joaquin, Stanislaus and Ventura Counties	.25
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.25
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.25
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.25
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.25
October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.25
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.25
July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	.25
October, 1927, Mines and Mineral Resources of Mono County	.25
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.25
April, 1928, Mines and Mineral Resources of Mariposa County	.25
**July 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.25
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.25
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.25
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.25
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.25
Chapters of Twenty-sixth Report of the State Mineralogist 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.25
April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	.25
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	$0.25
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative effects in Concrete	.25
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifer of the Kreyenhagen Shale. Geology of Santa Cruz Island	.25
July 1931, Mines and Mineral Resources of Yuba and San Bernardino Counties, Feldspar, Silica, Andalusite, and Cyanite Deposits of California. Andalusite in Mono County. Trinity-Klamath River Fish and Game District affects Mining. U. S. Mint Aids Prospectors	.25
October, 1931, Mines and Mineral Resources of Alpine County. Geology of San Jacinto Quadrangle South of San Gorgonio Pass. Mining Activity in Inyo and Mono Counties	.25
Subscription, $1.00 in advance (by calendar year, only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, June, **July, **August, **September, **October, November, **December, 1919	Free
January, February, March, April, **May, June, July, **August, September, October, November, December, 1920	Free
January, **February, **March, **April, May, June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1922	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1923	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, May, June, July, August, September, October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
January-February-March, April-May-June, July-August-September, 1930 (Published quarterly beginning July, 1929.)	Free

BULLETINS

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 1. A Description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of Californian Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887.)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means. 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms. 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
**Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	----
**Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	----
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	$0.50
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----

8—92845

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 29. Mineral Production of California for Sixteen Years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by Wm. Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 48. Mineral Production of California for Twenty Years, by Charles G. Yale. 1906	----
**Bulletin No. 49. Mines and Minerals of California for 1906, by Charles G. Yale. 34 pp.	----
Bulletin No. 50. The Copper Resources of California, 1908, by A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorne and J. A. Edman. 366 pp., 74 illustrations. (Revised edition.)	$1.00
**Bulletin No. 51. Mineral Production of California, by Counties, 1907, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 52. Mineral Production of California for Twenty-one Years, by D. H. Walker. 1907. Tabulated sheet	----
**Bulletin No. 53. Mineral Production of California for 1907, with County Maps, by D. H. Walker. 62 pp.	----
**Bulletin No. 54. Mineral Production of California, by Counties, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 55. Mineral Production of California for Twenty-two Years, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 56. Mineral Production for 1908, with County Maps and Mining Laws of California, by D. H. Walker. 78 pp.	----
**Bulletin No. 57. Gold Dredging in California, by W. B. Winston and Chas. Janin. 1910, 312 pp., 239 illustrations, 10 maps	----
**Bulletin No. 58. Mineral Production of California, by Counties, by D. H. Walker. 1909. Tabulated sheet	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 59. Mineral Production of California for Twenty-three Years, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 60. Mineral Production for 1909, with County Maps and Mining Laws of California, by D. H. Walker. 94 pp.	----
**Bulletin No. 61. Mineral Production of California, by Counties, for 1910, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 62. Mineral Production of California for Twenty-four Years, by D. H. Walker. 1910. Tabulated sheet	----
**Bulletin No. 63. Petroleum in Southern California, by P. W. Prutzman. 1912, 430 pp., 41 illustrations, 6 maps	----
**Bulletin No. 64. Mineral Production for 1911, by E. S. Boalich. 49 pp.	----
**Bulletin No. 65. Mineral Production for 1912, by E. S. Boalich. 64 pp.	----
**Bulletin No. 66. Mining Laws of the United States and California. 1914, 89 pp.	----
**Bulletin No. 67. Minerals of California, by Arthur S. Eakle. 1914, 226 pp.	----
**Bulletin No. 68. Mineral Production for 1913, with County Maps and Mining Laws, by E. S. Boalich. 160 pp.	----
**Bulletin No. 69. Petroleum Industry of California, with Folio of Maps (18 by 22), by R. P. McLaughlin and C. A. Waring. 1914, 519 pp., 13 illustrations, 83 figs. [18 plates in accompanying folio.]	----
**Bulletin No. 70. Mineral Production for 1914, with County Maps and Mining Laws. 184 pp.	----
**Bulletin No. 71. Mineral Production for 1915, with County Maps and Mining Laws, by Walter W. Bradley. 193 pp., 4 illustrations	----
**Bulletin No. 72. The Geologic Formations of California, by James Perrin Smith. 1916, 47 pp.	----
**Reconnaissance Geologic Map (of which Bulletin 72 is explanatory), in 23 colors. Scale: 1 inch = 12 miles. Mounted	----
**Bulletin No. 73. First Annual Report of the State Oil and Gas Supervisor of California, for the Fiscal Year 1915–16, by R. P. McLaughlin. 278 pp., 26 illustrations	----
**Bulletin No. 74. Mineral Production of California in 1916, with County Maps, by Walter W. Bradley. 179 pp., 12 illustrations	----
**Bulletin No. 75. United States and California Mining Laws. 1917, 115 pp., paper	----
Bulletin No. 76. Manganese and Chromium in California, by Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring. 1918, 248 pp., 51 illustrations, 5 maps, paper	$0.50
Bulletin No. 77. Catalogue of Publications of California State Mining Bureau, 1880–1917, by E. S. Boalich. 44 pp., paper	Free
Bulletin No. 78. Quicksilver Resources of California, with a Section on Metallurgy and Ore-Dressing, by Walter W. Bradley, 1919, 389 pp., 77 photographs and 42 plates (colored and line cuts), cloth	1.50
Bulletin No. 79. Magnesite in California, by Walter W. Bradley. 1925, 147 pp., 62 photographs, 11 line cuts and maps, cloth	1.00
†Bulletin No. 80. Tungsten, Molybdenum and Vanadium in California. (In preparation.)	
†Bulletin No. 81. Foothill Copper Belt of California. (In preparation.)	
**Bulletin No. 82. Second Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1916–1917, by R. P. McLaughlin. 1918, 412 pp., 31 illustrations, cloth	----
Bulletin No. 83. California Mineral Production for 1917, with County Maps, by Walter W. Bradley. 179 pp., paper	Free
**Bulletin No. 84. Third Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1917–1918, by R. P. McLaughlin. 1918, 617 pp., 28 illustrations, cloth	----
**Bulletin No. 85. Platinum and Allied Metals in California, by C. A. Logan, 1919. 10 photographs, 4 plates, 120 pp., paper	----
Bulletin No. 86. California Mineral Production for 1918, with County Maps, by Walter W. Bradley. 1919, 212 pp., paper	Free

† Not yet published.

9—92845

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

Price

**Bulletin No. 87. Commercial Minerals of California, with notes on their uses, distribution, properties, ores, field tests, and preparation for market, by W. O. Castello. 1920, 124 pp., paper ---- ----

Bulletin No. 88. California Mineral Production for 1919, with County Maps, by Walter W. Bradley. 1920, 204 pp., paper ---- Free

**Bulletin No. 89. Petroleum Resources of California, with Special Reference to Unproved Areas, by Lawrence Vander Leck. 1921, 12 figures, 6 photographs, 6 maps in pocket, 186 pp., cloth ---- ----

Bulletin No. 90. California Mineral Production for 1920, with County Maps, by Walter W. Bradley. 1921, 218 pp., paper ---- Free

Bulletin No. 91. Minerals of California, by Arthur S. Eakle. 1923, 328 pp. cloth ---- $1.00

**Bulletin No. 92. Gold Placers of California, by Chas. S. Haley. 1923 167 pp., 36 photographs and 7 plates (colored and line cuts, also geologic map), cloth ----
Extra copies of the Geologic Map (in 4 colors) ---- .50

Bulletin No. 93. California Mineral Production for 1922, by Walter W. Bradley. 1923, 188 pp., paper ---- Free

Bulletin No. 94. California Mineral Production for 1923, by Walter W. Bradley. 1924, 162 pp., paper ---- Free

Bulletin No. 95. Geology and Ore Deposits of the Randsburg Quadrangle, by Carlton D. Hulin. 1925, 152 pp., 49 photographs, 13 line cuts, 1 colored geologic map, cloth ---- 2.00

**Bulletin No. 96. California Mineral Production for 1924, by Walter W. Bradley. 1925, 173 pp., paper ---- ----

**Bulletin No. 97. California Mineral Production for 1925, by Walter W. Bradley. 1926, 172 pp., paper ---- ----

Bulletin No. 98. American Mining Law, by A. H. Ricketts. 1931, 810 pp., 24 illus., flexible leather ---- 2.00

Bulletin No. 99. Clay Resources and Ceramic Industry of California, by Waldemar Fenn Dietrich. 1928, 383 pp., 70 photos, 12 line cuts including maps, cloth ---- 1.50

**Bulletin No. 100. California Mineral Production for 1926, by Walter W. Bradley. 1927, 174 pp., paper ---- ----

**Bulletin No. 101. California Mineral Production for 1927, by Henry H. Symons. 1928, 311 pp., paper ---- ----

Bulletin No. 102. California Mineral Production for 1928, by Henry H. Symons. 1929, 210 pp., paper ---- Free

Bulletin No. 103. California Mineral Production for 1929, by Henry H, Symons, 1930. 231 pp., paper ---- Free

Bulletin No. 104. Bibliography of the Geology and Mineral Resources of California, to the end of 1929, by Solon Shedd, 1931. (Preliminary Edition only, subject to revision) ---- Free

Bulletin No. 105. California Mineral Production for 1930, by Henry H. Symons, 1931. 229 pp. paper ---- Free

Bulletin No. 106. Manner of Locating and Holding Mineral Claims in California (with forms), by A. H. Ricketts, 1931. 20 pp., paper ---- .25

PRELIMINARY REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**Preliminary Report No. 1. Notes on Damage by Water in California Oil Fields, December, 1913. By R. P. McLaughlin. 4 pp.	----
**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin. 4 pp.	----
Preliminary Report No. 3. Manganese and Chromium, 1917. By E. S. Boalich. 32 pp.	Free
**Preliminary Report No. 4. Tungsten, Molybdenum and Vanadium. By E. S. Boalich and W. O. Castello, 1918. 34 pp. Paper	----
**Preliminary Report No. 5. Antimony, Graphite, Nickel, Potash, Strontium and Tin. By E. S. Boalich and W. O. Castello, 1918. 44 pp. Paper.	----
Preliminary Report No. 6. A Review of Mining in California During 1919. By Fletcher Hamilton, 1920. 43 pp. Paper	Free
**Preliminary Report No. 7. The Clay Industry in California. By E. S. Boalich, W. O. Castello, E. Huguenin, C. A. Logan, and W. B. Tucker, 1920. 102 pp. 24 illustrations. Paper	----
**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----
**Catalogue of the Library of the California State Mining Bureau, September 1, 1892. 149 pp.	----
**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper.	----
Bulletin. Reconnaissance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper.	Free
Commercial Mineral Notes. A monthly mimeographed sheet, beginning April, 1923	Free

MAPS

Register of Mines With Maps.

Asterisks (**) indicate the publication is out of print.

	Price
**Register of Mines, with Map, Amador County	----
**Register of Mines, with Map, Butte County	----
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
**Register of Mines, with Map, Inyo County	----
**Register of Mines, with Map, Kern County	----
**Register of Mines, with Map, Lake County	----
**Register of Mines, with Map, Mariposa County	----
**Register of Mines, with Map, Nevada County	----
**Register of Mines, with Map, Placer County	----
**Register of Mines, with Map, Plumas County	----
**Register of Mines, with Map, San Bernardino County	----
**Register of Mines, with Map, San Diego County	----
Register of Mines, with Map, Santa Barbara County (1906)	$0.25
**Register of Mines, with Map, Shasta County	----
**Register of Mines, with Map, Sierra County	----
**Register of Mines, with Map, Siskiyou County	----
**Register of Mines, with Map, Trinity County	----
**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.25
Register of Oil Wells, with Map, Los Angeles City (1906)	.35

OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----
Geological Map of California, 1916. Scale 1 inch equals 12 miles. As accurate and up-to-date as available data will permit as regards topography and geography. Shows railroads, highways, post offices and other towns. First geological map that has been available since 1892, and shows geology of entire state as no other map does. Geological details lithographed in 23 colors. Unmounted	.75
Mounted	2.00
Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	.50

OIL FIELD MAPS

These maps are revised from time to time as development work advances and ownerships change.

	Price
Map No. 1—Sargent, Santa Clara County	$0.50
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	.75
Map No. 3—Santa Maria, including Casmalia and Lompoc	.75
Map No. 4—Whittier-Fullerton, including Olinda, Brea Canyon, Puente Hills, East Coyote and Richfield	.75
Map No. 5—Whittier-Fullerton, including Whittier, West Coyote and Montebello	.75
Map No. 6—Salt Lake, Los Angeles County	.75
Map No. 7—Sunset and San Emidio and Kern County	.75
Map No. 8—South Midway and Buena Vista Hills, Kern County	.75
Map No. 9—North Midway and McKittrick, Kern County	.75
Map No. 10—Belridge and McKittrick, Kern County	.75
Map No. 11—Lost Hills and North Belridge, Kern County	.75
Map No. 12—Devils Den, Kern County	.75
Map No. 13—Kern River, Kern County	.75
Map No. 14—Coalinga, Fresno County	1.00
Map No. 15—Elk Hills, Kern County	.75
Map No. 16—Ventura-Ojai, Ventura County	.75
Map No. 17—Santa Paula-Sespe Oil Fields, Ventura County	.75
Map No. 18—Piru-Simi-Newhall Oil Fields	.75
Map No. 19—Arroyo Grande, San Luis Obispo County	.75
Map No. 20—Long Beach Oil Field	1.25
Map No. 21—Portion of District 4, Showing Boundaries of Oil Fields, Kern and Kings counties	.75
Map No. 21A—Portion Kern and Kings counties	.75
Map No. 22—Portion of District 3, Showing Oil Fields, Santa Barbara County	.75
Map No. 23—Portion of District 2, Showing Boundaries of Oil Fields, Ventura County	.75
Map No. 24—Portion of District 1, Showing Boundaries of Oil Fields, Los Angeles and Orange counties	.75
Map No. 26—Huntington Beach Oil Field	.75
Map No. 27—Santa Fe Springs Oil Field	.75
Map No. 28—Torrance, Los Angeles County	.75
Map No. 29—Dominguez, Los Angeles County	.75
Map No. 30—Rosecrans, Los Angeles County	.75
Map No. 31—Inglewood, Los Angeles County	.75
Map No. 32—Seal Beach, Los Angeles and Orange counties	.75
Map No. 33—Rincon, Ventura County	.75
Map No. 34—Mt. Poso, Kern County	.75
Map No. 35—Round Mountain, Kern County	.75
Map No. 36—Kettleman Hills, Kings County	1.25
Map No. 37—Montebello, Los Angeles County	.75
Map No. 38—Whittier, Los Angeles County	.75
Map No. 39—West Coyote, Los Angeles and Orange counties	.75
Map No. 40—Elwood, Santa Barbara County	.75
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

o

92845 4-32 2M

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT
ITS VARIOUS DEPARTMENTS MAINTAINED
FOR THE PURPOSE OF FURTHERING
THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

At the service of the public are the scientific reference library and reading room, the general information bureau, the laboratory for the free determination of mineral samples found in the State, and the largest museum of mineral specimens on the Pacific Coast. The time and attention of the State Mineralogist, as well as that of his technical staff, are also at your disposal.

Office hours: 9 a.m. to 5 p.m. daily.
Saturday, 9 a.m. to 12 m.

WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal.
Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.

Mining in California

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

EXECUTIVE AND TECHNICAL STAFF

WALTER W. BRADLEY
State Mineralogist

OLAF P. JENKINS, Chief Geologist - - - - - -	San Francisco
C. A. LOGAN, District Mining Engineer - - - - -	Sacramento
C. McK. LAIZURE, District Mining Engineer - - - -	San Francisco
W. BURLING TUCKER, District Mining Engineer - - - -	Los Angeles
REID J. SAMPSON, Assistant District Engineer - - - -	Los Angeles
CHAS. V. AVERILL, District Mining Engineer - - - -	Redding
FRANK SANBORN, Mineral Technologist - - - - -	San Francisco
HENRY H. SYMONS, Statistician and Curator - - - -	San Francisco
HERBERT A. FRANKE, Junior Mining Engineer (Librarian) -	San Francisco

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
D. H. BLOOD, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

Vol. 28 — APRIL, 1932 — No. 2

CHAPTER OF

REPORT XXVIII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1932

TABLE OF CONTENTS

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923.

For the same reason, beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

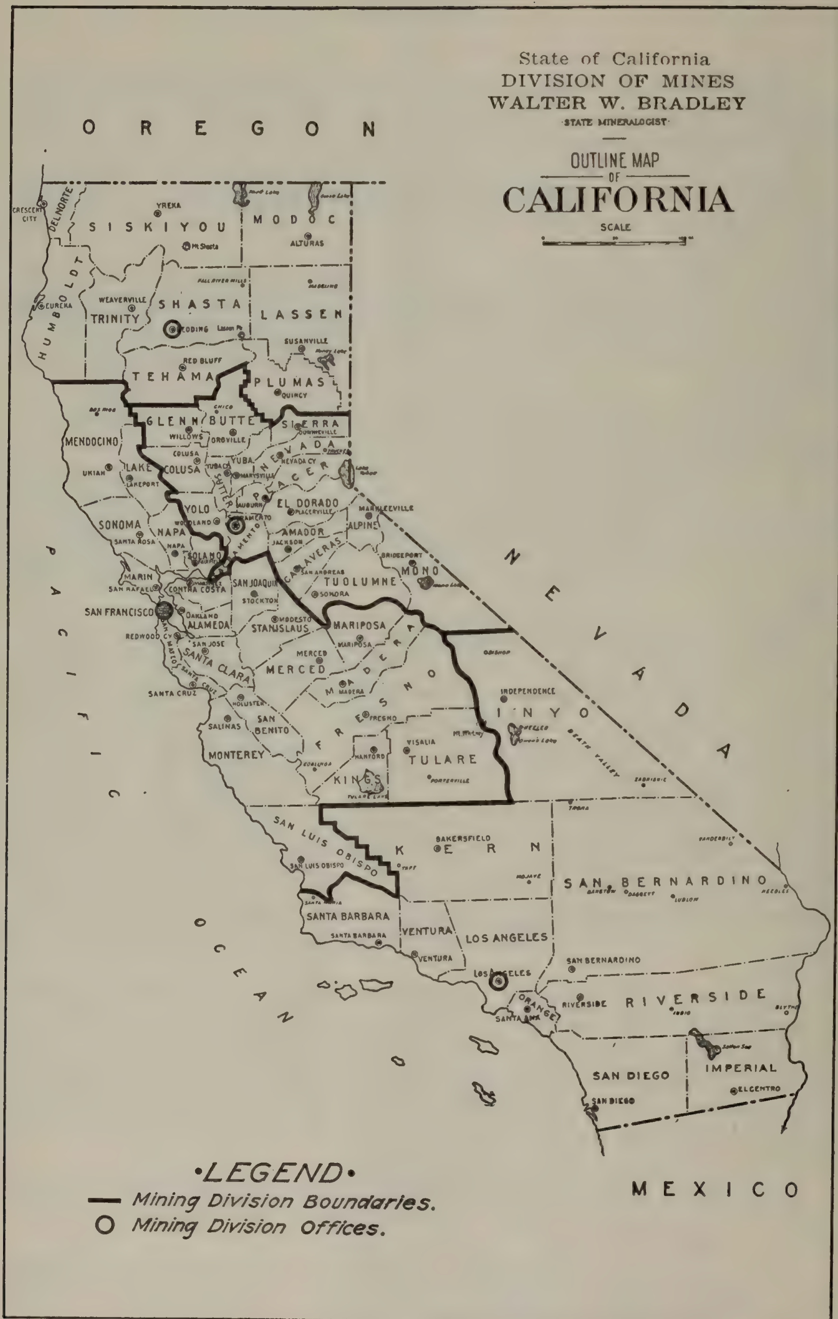
Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.


State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
OREGON
NEVADA
MEXICO
PACIFIC
OCEAN
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
PLACER
SUTTER
YOLO
EL DORADO
ALPINE
SONOMA
NAPA
SACRAMENTO
AMADOR
SOLANO
CALAVERAS
MONO
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
FRESNO
INYO
SAN BENITO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
CRESCENT CITY
YREKA
ALTURAS
EUREKA
WEAVERVILLE
REDDING
SUSANVILLE
RED BLUFF
QUINCY
WILLOWS
OROVILLE
UKIAH
LAKEPORT
NEVADA CY
MARYSVILLE
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
SANTA ROSA
NAPA
JACKSON
BRIDGEPORT
SAN RAFAEL
SAN ANDREAS
SONORA
STOCKTON
OAKLAND
MODESTO
REDWOOD CY
SAN JOSE
MERCED
INDEPENDENCE
SANTA CRUZ
HOLLISTER
FRESNO
SALINAS
VISALIA
HANFORD
DEATH VALLEY
BAKERSFIELD
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XIV to XVII, inclusive, in the case of many of the counties have become exhausted. Beginning with the January, 1925, issue of 'Mining in California,' these have been revised and brought up to date, by presenting the district engineers' reports each in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This county series was completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, was begun in 1931, and will be added to in future issues. Papers by the Geological Branch and other county reports are also included.

REDDING FIELD DIVISION

CHAS. V. AVERILL, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the Redding field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

SACRAMENTO FIELD DIVISION

C. A. Logan, Mining Engineer

Mr. C. A. Logan, District Engineer, has been engaged during the past three months in the preparation of a special report upon the Mother Lode of California, which will be published during the current year.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DIVISION

W. B. Tucker and R. J. Sampson, Mining Engineers

Reports covering the mines and mineral resources of all of the counties in the Los Angeles field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

GEOLOGIC BRANCH

PROGRESS REPORT

Olaf P. Jenkins, Chief Geologist

The work of the Geologic Branch of the California State Division of Mines comprises field investigations and the preparation of reports on the geologic history of the rocks and mineral deposits of the State. A systematically arranged and well-indexed bibliography of all publications on the geology and mineral resources of California is now in press. A general but very accurate geologic map of the State on the scale of eight miles to the inch is gradually being assembled. Several reports on special problems or areas are in preparation, and some of these are nearly ready for the press. In each case the project represents cooperative work between the State and some other institution or individual.

The field investigations which are to be in progress during this summer of 1932 may be listed as follows:

Continuation of geologic study (mapping, etc.)

1. Searles Lake quadrangle (San Bernardino, Inyo and Kern counties), by C. D. Hulin.
2. Southwestern Mono County, by Evans B. Mayo.
3. Amboy quadrangle, San Bernardino County, by J. C. Hazzard.
4. Lucia quadrangle, Monterey County, by Parry Reiche.
5. Geology of the Hetch Hetchy coast tunnels, Alameda County, by George Green.
6. Geology of Northern California in region of Covelo, Mendocino and Tehama counties, by Samuel Clark.
7. Physiographic studies in California, by W. M. Davis.

New Projects

8. Geology and mineral deposits of the borax district about Kramer (San Bernardino County), by A. A. Fitch.
9. Geology and ore deposits of the Bodie District (Mono County), by F. H. Frederick.
10. Geology and ore deposits of the Julian District (San Diego County), by Maurice Donnelly.
11. A study of the stratigraphy and geologic history of the Cretaceous deposits of California, by F. M. Anderson, together with the Chief Geologist.
12. A technical and geologic study of the silica sand deposits of California, by E. Wayne Galliher, together with the Chief Geologist.

OIL FIELD DEVELOPMENT OPERATIONS

By R. D. Bush, State Oil and Gas Supervisor

From January 3, 1932, to and including April 2, 1932, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
FRESNO COUNTY:					
P. H. Cook	12	21	14	3	Coalinga
Kettleman North Dome Association	20	21	17	58	Kettleman Hills
North Kettleman Oil & Gas Co.	24	21	16	1	Kettleman Hills
Superior Oil Co.	29	21	17	Huffman 4	Kettleman Hills
KERN COUNTY:					
Milham Exploration Co.	7	28	23	S. P. 21-7	Buttonwillow Gas
Milham Exploration Co.	8	28	23	Whitaker 1	Buttonwillow Gas
Ray W. Taylor	29	25	19	1	Devils Den
Bankline Oil Co.	21	29	27	1	Fruitvale
Bankline Oil Co.	21	29	27	2	Fruitvale
Hay Petroleum Corp., Ltd.	23	29	27	1	Fruitvale
Mohawk Petroleum Co.	21	29	27	8	Fruitvale
Mohawk Petroleum Co.	21	29	27	9	Fruitvale
Plymouth Oil Co.	23	29	27	Fruitvale 2	Fruitvale
Seahawk Petroleum Co., Ltd.	23	29	27	2-A	Fruitvale
Seahawk Petroleum Co., Ltd.	23	29	27	2-B	Fruitvale
Western Gulf Oil Co.	21	29	27	Carpenter 1	Fruitvale
Western Gulf Oil Co.	21	29	27	Rea 1	Fruitvale
Western Gulf Oil Co.	22	29	27	11-KCL-B	Fruitvale
C. C. M. O. Co.	23	28	27	40	Kern River
Thos. H. T. Purman	28	29	21	Cymric 2	McKittrick
Republic Petroleum Co., Ltd.	7	32	23	35-A	Midway
Standard Oil Co.	35	31	23	108	Midway
Standard Oil Co.	33	31	24	105	Midway
A. S. Mayes	36	27	28	1	Mt. Poso
Modoc Petroleum, Ltd.	28	26	28	Modoc 1	Mt. Poso
Hoke Woodward	4	27	28	1	Mt. Poso
C. C. M. O. Co.	6	28	29	5	Round Mountain
California Western Oil Co., Ltd.	7	28	29	7	Round Mountain
California Western Oil Co., Ltd.	7	28	29	9	Round Mountain
A. S. Mayes	6	28	29	2	Round Mountain
Descanso Co., Ltd.	31	11	19	1	
KINGS COUNTY:					
Powell-Stockton Inv. Co., Ltd.	32	22	19	2	Kettleman Hills
Powell-Stockton Inv. Co., Ltd.	32	22	19	3	Kettleman Hills
Eagle Oil & Gas Co.	15	23	20	2	
Magee and Stone	34	24	22	1	
Scott Bros. Well Drilling Co.	18	22	19	1	
H. C. Turnham	23	20	22	1	
LOS ANGELES COUNTY:					
Standard Oil Co.	13	3	11	Emery 51	Coyote Hills
Republic Petroleum Co., Ltd.	34	3	13	Republic Childs 1	Dominguez
Shell Oil Co.	34	3	13	Reyes 42	Dominguez
Union Oil Co.	33	3	13	Callender 28	Dominguez
Union Oil Co.	33	3	13	Callender 29	Dominguez
Union Oil Co.	33	3	13	Carson 5	Dominguez
Union Oil Co.	33	3	13	Hellman 18	Dominguez
Standard Oil Co.	17	2	14	L.A.Invest. 1 68	Inglewood
R. R. Bush Oil Co.	30	4	12	Arenz 1	Long Beach
The Ohio Oil Co.	28	2	15	Recreation Gun Club 12	Playa del Rey
Union Oil Co.	27	2	15	Del Rey 4	Playa del Rey
M. C. Frantz	4	3	11	1	Santa Fe Springs
Standard Oil Co.	3	5	12	San Gabriel 25	Seal Beach
Walter I. Barcus	28	4	13	Lupie 1	
L. C. Hunt	29	3	14	1	
Albert Stevenson	21	4	14	1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
ORANGE COUNTY:					
Orangethorpe Corp.	32	3	10	1	----------
SAN DIEGO COUNTY:					
C. H. Shannon	14	15	3	Mack 1	----------
SANTA BARBARA COUNTY:					
General Petroleum Corp.	3	4	29	Hollister 1	Goleta
Barnsdall Oil Co.	31	8	33	Careaga 1	Santa Maria
Union Oil Co.	25	9	34	Newlove 51	Santa Maria
TULARE COUNTY:					
Western Natural Resource Corp. and E. B. Guess	7	23	23	3	----------
VENTURA COUNTY:					
Union Oil Co.	3	3	19	Calumet 1	Bardsdale
Bardeen Petroleum Co., Ltd.	13	4	19	2–B	Piru
R. R. Renaud	25	3	18	Marr 17	Simi
Associated Oil Co.	26	3	23	V. L. & W. 20	Ventura
Associated Oil Co.	27	3	23	Lloyd 131	Ventura
Shell Oil Co.	29	3	23	Taylor 73	Ventura

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of MINING IN CALIFORNIA.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

ELEMENTARY PLACER MINING METHODS AND GOLD-SAVING DEVICES

By C. McK. LAIZURE, District Mining Engineer

Introduction

The year 1930 witnessed a marked revival in small-scale placer gold-mining operations in California. The State's gold production increased from $8,526,703 in 1929 to $9,451,162 in 1930, and the number of placer gold mines reporting production increased from 478 to 892. The latter figure does not include the many transient individuals and small groups who worked with pan, rocker, sluice-box or dry washer, on bars, in stream beds and gulches, or in the arid regions throughout the gold-bearing areas, but their accumulated 'dust' undoubtedly formed a substantial part of the increase. The estimated gold production for 1931 is $10,708,000 and it is believed that at least 10,000 persons were thus engaged in hand-mining for various periods during that year. They recovered from 50 cents to several dollars a day, each, the returns depending upon their location, energy, experience, equipment, and to no small degree, luck.

The day is definitely past in California, however, when an individual can go out and count on obtaining even day wages by hand-mining for placer gold. Regardless of this, and due largely to the unemployment situation it appears that an even larger number of 'amateur' placer miners will be busy during 1932, preferring it to idleness. This statement is confirmed by the increasing number of personal and written inquiries coming to the Division of Mines for information as to localities where placer gold may be found, how it can be recovered, where sold, manner of locating claims and many other related questions.

This article has been prepared primarily for the novice and those with little experience or technical training. Elaborate treatises on hydraulic mining, gold dredging and other forms of placer mining requiring large capital expenditure are available to operators of that class. The equipment described herein and in the accompanying article, with the exception of some of the larger machines, will cost only from one dollar to a few hundred dollars, and some of it can be homemade.

Placer Mining Areas in California

On the outline map of California herewith the general areas in which placer operations are apt to be most remunerative, are indicated by shading. Dry and semi-dry washing methods largely prevail in the region south of Tehachapi Pass on account of the shortage of water.

Practically all that remains in placer mining for the man without capital is the gleaning of the fine gold which is brought down annually by the streams. Some of this is new gold washed from the hills but it is mostly gold that was lost from the early day mines. Mining of this kind is possible usually only during the dry season, from June to November, when the streams reach a low stage, permitting the miner to scrape up and wash the thin layer of gravel deposited along the banks of the rivers during high water. The river banks in the gold regions have been worked repeatedly, and it seldom pays to work over a foot in depth in such places. With a rocker, dip box or short sluice, a dollar a day or less may be expected from such ground; in exceptional cases, and with hard work, sometimes more can be recovered.

The rivers on which most of the small-scale placer mining is done are the following, from south to north:

River	*Reached by way of*
Stanislaus	Knights Ferry or San Andreas
Mokelumne	Lockeford or Jackson
Cosumnes	Plymouth or Lodi
American, South Fork	Folsom
American, North and Middle Forks	Auburn or Colfax
Bear	Lincoln or Dutch Flat
Yuba (lower part)	Marysville
Yuba (upper branches)	Nevada City
Feather	Oroville or Quincy
Trinity	Redding and Weaverville
Klamath	Yreka and Hornbrook
Salmon	Etna Mills and Somes Bar
Smith	Crescent City

It will be found that much of the land along these streams is either patented or held as unpatented mining claims and is private property; such private property lines or unpatented mining claim boundaries may take in the bed or banks of an unnavigable river.

Detailed reports describing the mines and mineral resources of individual counties are contained in the quarterly chapters of the State Mineralogist's Report XXI to XXVII, 1925 to 1931. A list of these will be found in the Bibliography, by Herbert Franke, in this issue of 'Mining in California.' Bulletin No. 92 'Gold Placers of California' is a general report covering the State. (Out of print but

available for reference in many of the larger libraries throughout this and other States.) The subject of localities in which to prospect will not be considered further herein.

Simple Placer Mining Equipment

In the early-day working of virgin ground it was possible to recover a large proportion of the gold by very simple appliances and without great effort or expert knowledge. The methods used included use of the miners pan or batea, the rocker or cradle, the long tom, ground sluicing and the riffle-box or sluice. The use of and construction of these simpler devices are described and illustrated in an accompanying article by H. H. Symons.

As the richer deposits became worked out and the recovery of payable quantities of gold became more and more difficult, new mining methods were developed and special processes and machines were devised to meet the changed conditions. Later mining methods included booming, hydraulicking, dredging, beach-sand work, dry-washing, mechanical handling and drifting. References to methods not described here, will be found in the bibliography previously mentioned.

Perhaps the lightest equipment of all, consists of a tin can, cup, or small bottle and a pair of tweezers. With these the 'crevicer' during times of low water, picks the grains and flakes of gold from the cracks and crevices in schistose and slatey bed rock where it is crossed by stream courses, and saves it. Heavier equipment includes various-shaped gouges and bars, scrapers, scoops, and the much-pictured pick and shovel. Whisk-brooms and wire brushes are used to aid in gathering the finer material into the gold pan for cleaning. Another primitive class of mining is known as moss-mining or 'mossing.' The moss growing on the rocks in some streams catches and holds appreciable amounts of fine gold. This moss is gathered and the gold shaken out, or it is burned and the ashes either panned, or winnowed; as the grain was winnowed from the chaff by the wind, in biblical times. 'Winnowing' is also practiced to some extent in the dry desert areas.

SPECIAL MACHINES AND PROCESSES

Some placer deposits contain only heavy gold; in others the gold is in a very finely-divided state or accompanied by large amounts of heavy black sand; or the deposit may be situated in a region where no water is available for working. To meet these various conditions numerous schemes have been proposed and new devices developed to increase the efficiency of recovery.

The inventors of fine or 'flour' gold and platinum machines, 'black-sand' machines and other gold-saving devices are legion in number. There is said to be more than 7000 of them patented. Some of these schemes are little more than 'ideas,' others have been developed to a point where they may be shown on paper. Some have been built and tried out with more or less success under certain conditions, and a few machines or appliances have proved their worth, are being manufactured on a commercial scale and have been adopted as valuable additions to the technology of placer gold mining.


STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
SHOWING MOST IMPORTANT
PLACER MINING AREAS
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
DEL NORTE
CRESCENT CITY
SISKIYOU
YREKA
Mt Shasta
MODOC
ALTURAS
Goose Lake
HUMBOLDT
EUREKA
TRINITY
WEAVERVILLE
SHASTA
REDDING
Lassen Pk
FALL RIVER MILLS
LASSEN
MADELINE
SUSANVILLE
Honey Lake
TEHAMA
RED BLUFF
PLUMAS
QUINCY
GLENN
BUTTE
CHICO
WILLOWS
OROVILLE
SIERRA
DOWNIEVILLE
MENDOCINO
UKIAH
LAKE
LAKEPORT
COLUSA
YUBA
NEVADA
NEVADA CY
TRUCKEE
Lake Tahoe
SUTTER
MARYSVILLE
PLACER
AUBURN
EL DORADO
PLACERVILLE
MARKLEEVILLE
ALPINE
YOLO
WOODLAND
SACRAMENTO
SONOMA
SANTA ROSA
NAPA
AMADOR
JACKSON
SOLANO
FAIRFIELD
CALAVERAS
SAN ANDREAS
BRIDGEPORT
MONO
Mono Lake
MARIN
SAN RAFAEL
MARTINEZ
CONTRA COSTA
SAN JOAQUIN
STOCKTON
TUOLUMNE
SONORA
SAN FRANCISCO
OAKLAND
ALAMEDA
MODESTO
STANISLAUS
MARIPOSA
REDWOOD CY
SAN MATEO
SAN JOSE
SANTA CLARA
MERCED
MADERA
BISHOP
SANTA CRUZ
HOLLISTER
FRESNO
INDEPENDENCE
INYO
KEELER
Owen's Lake
Mt Whitney
DEATH VALLEY
SALINAS
SAN BENITO
VISALIA
TULARE
MONTEREY
HANFORD
COALINGA
KINGS
TULARE LAKE
PORTERVILLE
ZABRISKIE
TRONA
SAN LUIS OBISPO
KERN
BAKERSFIELD
TAFT
VANDERBILT
MOJAVE
SAN BERNARDINO
BARSTOW
DAGGETT
LUDLOW
NEEDLES
SANTA MARIA
SANTA BARBARA
VENTURA
LOS ANGELES
RIVERSIDE
INDIO
ORANGE
SANTA ANA
Salton Sea
IMPERIAL
EL CENTRO
SAN DIEGO

A number of these methods and machines have come to the attention of the Division of Mines in the past several years. During the same period numerous inquiries have been received from persons wishing to learn of any new process or machine that promised success in solving their recovery problem.

It is thought that the ingenuity shown will be of interest even to the layman and that the information given herein will be not only of interest but of practical value, in at least some instances, to the owners and operators of placer deposits, and to prospectors.

In no instance has any special machine, device or process here described been tested or approved by the Division of Mines, although some of them have been observed in operation by representatives of the division. Their merits or faults and suitability for any given conditions must be determined by those directly interested.

The information given has been obtained in most cases from the inventor, owner or manufacturer of the machine or proponent of the process, from advertising matter, and from users, or it has been gathered from various published articles.

The Division of Mines therefore can not assume responsibility for any claims or statements made.

The name and last known address of the party exploiting any of these processes and machines will be supplied upon request.

SPECIAL RECOVERY PROCESSES AND MACHINES

No. 1. Acosta Placer Mining Machine. This contrivance consists of a sluice box and a concentrator together with a gasoline engine, a barrel of water and hydraulic vibrator mounted on one side of the concentrator, which makes of this concentrator virtually a self-shaking gold pan.

Each unit of the machinery has a new feature except the gasoline engine which is of 20-h.p. capacity, although only 8 pounds of water pressure is needed to operate the vibrator. Therefore the engine and pump may be run at idling speed with a minimum of heat and wear. The barrel of water is used over and over again in operating the machinery.

The sluice box has new features incorporated in its construction. About 12 feet long, it leads from a box in which rollers break up the coarse lumps sending it into a specially divided hopper at the upper end of the sluice box from where it is shaken downward along the box by the constant shaking of the concentrator upon which is mounted the lower end of the sluice box. There are seven screened-opening 'riffles' at regular intervals along the 12-foot length of box, each permitting coarse gold to filter through into a small metal trough under the box and leading to the concentrator. Some of the fine gold particles will stick in the wood openings and there be reclaimed while others will accompany the coarse into the concentrator. The coarse rock particles roll on over the screens into a pile beyond the concentrator after the gold is shaken out.

The concentrator is unique in that it is mounted on four coil spring shock absorbers retrieved from the rear of old model T Ford cars, and is shaken by an ingenuous device invented by Mr. Acosta and mounted on one corner of the widened hopper which is the top of the concentrator box and made of metal.

This vibrator is a metal cylinder made from a vacuum tank used on cars a few years ago before force feed was adopted generally in carburation. Water pumped from the barrel goes through this vibrator at any designated speed, operating a diaphragm which causes the entire concentrator to vibrate, thus shaking the finer particles of gold dust and sifting it out of the coarser rock particles over a fine screen.

The two grades of gold are handled differently, the coarser grade being shaken into one channel and the finer going below where it drops into a bottle of mercury below the box and is thus concentrated, while the coarser is emptied through a side opening into another container.

No. 2. Ainlay Centrifugal Gold Separator. The Ainlay Centrifugal Gold Separator saves fine flake and 'rusty' gold, with a very high per cent of recovery, in most cases, being 95% or better. It works equally well on coarse gold, platinum and amalgam.

The principle of the Ainlay machine is simple and positive. The separation is made in a revolving bowl mounted under a revolving screen equipped with sufficient power to also operate a centrifugal pump furnishing water for the operation.

Material is fed through a hopper into the revolving screen, permitting that portion of the charge to screen into the bowl. A small quantity of water is fed into the screen through a perforated pipe, washing the charge thoroughly and passing into the bowl with the fine material. Centrifugal force holds the values securely in the riffles but permits the wasted material to pass over the top of the bowl. The cleanup is easily made through a plug valve in the bottom of the bowl.

The Ainlay machine completely does away with the 'black sand' problem. Can clean up in five minutes at any time—which is a tremendous advantage in testing ground. No mercury, electric current or chemicals are used. Cheap to operate. One gallon of gas will run the 12-inch machine six to eight hours.

Slow speed and best workmanship insure long life, with few adjustments. Especially adapted to arid regions, as it requires but 15 gallons of water per minute and the water can be used over and over again. Muddy water does not affect the recovery in the least. It is also adapted for use in milling free gold ores.

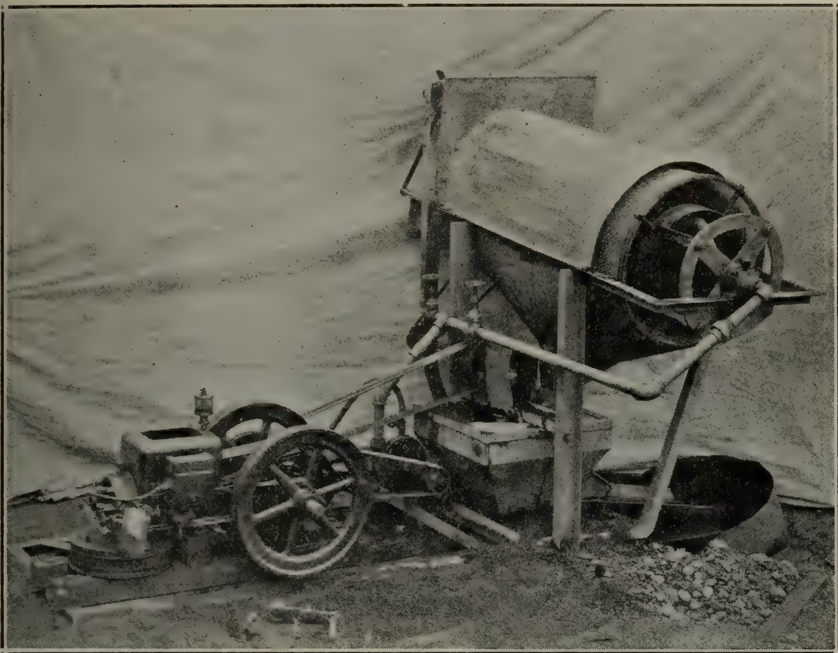
Anyone can operate it from the printed instructions. It is foolproof. Capacity of 12-inch machine, two or three cubic yards per hour bank run, depending upon character of gravel.

The 12-inch machine complete with gasoline engine, screen, pump, etc., weighs 800 lbs.; mounted on a trailer to be attached to an auto or wagon, 870 lbs.

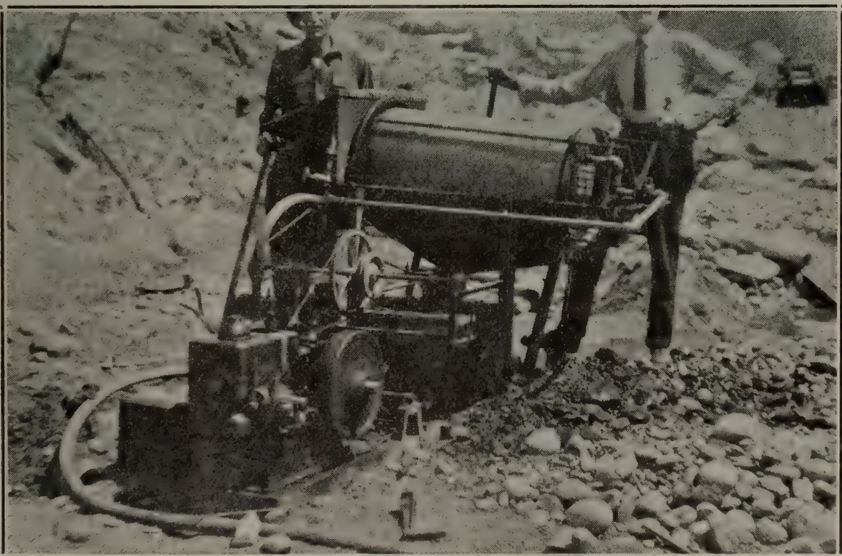
	Capacity per hour in yards	*Water used per minute*	*Power*	*Weight*	*Price*
Model A	2 to 3	15 gals.	3 h.p.	800 lbs.	$700 00
Trailer				70 lbs.	50 00
Model C	10 to 20	55 gals.	$11\frac{1}{2}$ h.p.	2,000 lbs.	935 00

Delivered at railroad station in California or Nevada.
Capacity given refers to bank run.

A Model 'A' machine is set up in San Francisco, for demonstration purposes.



No. 2. Ainlay Centrifugal Gold Separator, Model A.

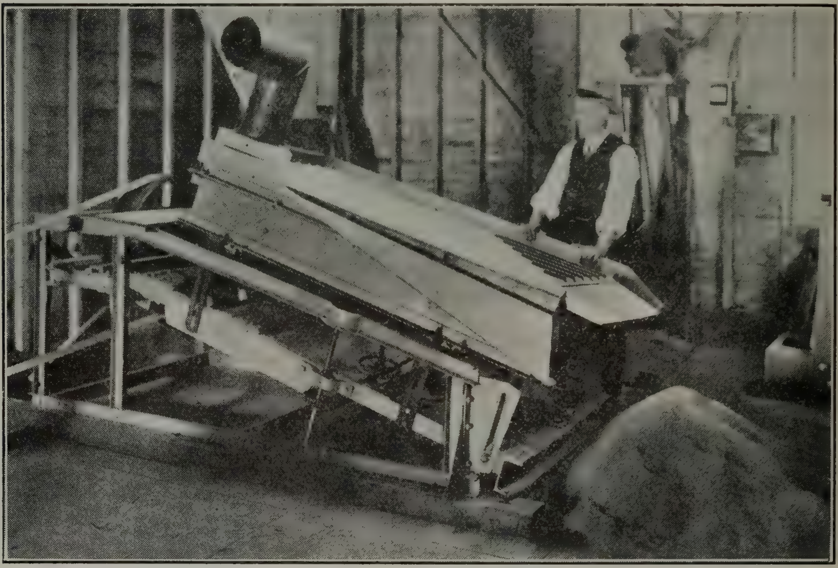


No. 2. Ainlay Machine ready for operation.

No. 3. American Dry Concentrating Company, of which Walter Duisenberg is president, has in recent years perfected a dry machine, which works solely by intermittent air pulsation. The riffles are diagonally placed, the table is self-clearing and cleaning, and one table will handle from 60 to 100 tons per 24 hours. This table has been thoroughly tested in the field and is said to be an absolute commercial success.

In a test run made by Abbot A. Hanks, Inc., this firm states in their report as follows:

* * * "Figured back against the original ton of gravel, the value recovered in the concentrate indicates that the gravel used in this test is worth $2.18 per ton. As stated above, the entire tailing from the test was carefully sampled and a sample of some 60 pounds taken to our laboratory for assay. Special assays were made on this tailing in duplicate. These checked exactly and showed a gold value remaining in the tailing of 6/10 of 1 cent per ton of tailing." * * *



No. 3. Side view of Concentrator of the American Dry Concentrating Co.

This machine it is claimed will successfully concentrate platinum, gold, tungsten or any other materials that have a reasonable amount of specific gravity.

No. 4. Australian Dry Blowers and Jiggers. Various types of dry blowers have been extensively used in the placer gold fields of Australia. These machines are hand operated and in most cases are mounted on wheelbarrow frames so they may be readily moved about.

The *Buhre Dry Blower, Carlson Dry Blower* and *Rankine Dry Blower* are illustrated and their construction described, together with that of dry-jiggers in the Engineering and Mining Journal, October 11, 1902, to which those interested are referred for details.

No. 5. Beach Sand Concentrator. One of the simplest types of machine used on beach sands consists of a plain duckboard riffle fastened to a plank bottom, which is set out near the edge of the sea

as the tide is coming in, and is kept constantly in such a position that the outgoing waves will wash the gold-bearing black sands over it. This machine has been used near Crescent City, and has paid day wages to the men operating it.[1] It is held down with rocks to prevent floating. An illustration of one of these surf washers and instructions for building it, by G. E. Elffner, is given in the Mining and Scientific Press, June 6, 1903, page 364.

No. 6. Bennett Air Gold Saver. The inventor of this machine spent a number of years as a prospector and field scout for mining corporations in Lower California, Mexico, and other waterless regions containing dry placer gold deposits. He was later engaged in the construction of large pipe organs. Combining his knowledge of the use and handling of air in pipe-organ work with his realization of the usefulness of a dry placer machine for such districts, he developed the Bennett air gold saver. This machine is said to differ from most dry washers in that it uses a pressure box, the vibrating air column being under pressure, the action of the machine somewhat resembling that of a jig. On account of the suspension of the material by the air pressure during its travel through the machine there is practically no wear on the special cloth under the riffles.

It is stated that damp as well as absolutely dry gravel can be successfully treated and 85% recovery of all gold obtained. The practicability of the Bennett air gold saver has been demonstrated at Quartz Mountain, Nevada, and near Oatman, Arizona, where dry placers have been worked successfully. The complete machine weighs about 375 pounds. Test runs will be made in Berkeley.

No. 7. The Berden Pan. This is not a new device. It has been long known and has been described in Engineering and Mining Journal[2] several times, but still there are probably many mine operators who are not familiar with it.

It is a valuable adjunct to a mill in cleaning up but is also useful in treating black sands for the recovery of fine gold, due to its grinding action and scouring effect on 'rusty' gold.

The standard size of Berdan pan is about 5 feet in diameter. The pan consists of a circular trough mounted on a steel driving shaft set at an angle in a frame and driven by gearing at a speed of from 10 to 15 revolutions per minute. A large ball travels in the circular trough as it revolves. The material to be treated is fed in continuously by automatic feeder or at intervals by hand, and a stream of water enters with the feed and continuously overflows from the lowest point on the lip, carrying off the tailing. The fineness to which the material is ground can be regulated within certain limits by the amount of water admitted.

The ball, which weighs about 120 pounds, rolls in a pool of mercury so that any free gold or 'rusty' gold that has been brightened by the grinding action will be immediately brought into contact with the quicksilver and amalgamated. The speed is so slow and action so quiet that practically no quicksilver is floured.

[1] Haley, Chas. S., Gold Placers of California. California State Mining Bureau. Bull. No. 92, 1923.

[2] Engineering and Mining Journal, New York, Vol. 106, No. 25, Dec. 21, 1918, and Vol. 125, No. 19, May 12, 1928.

A change, considered an improvement by some operators, consists in using a drag suspended so as to hang in the edge of the quicksilver pool instead of the ball which rolls in the mercury.

The actual grinding capacity of the pan is small, but it is well adapted for treating small lots of black sand, concentrates or finely-ground free-gold ore. The power required is negligible.

No. 8. Black Sand Process. This company, located in Vancouver, B. C., states that they have a special process for recovery of precious metals from black sand. No other information concerning it has been supplied.

No. 9. Brewer Dry Washer. This machine as used at Summit diggings, Kern County, is shown in the photo herewith. It is of the same general type as the Brewer new gold pan and dry washer, though developed by a different party with a similar name. A smaller folding hand-portable machine is also made.

No. 9. Brewer Dry Washer, Summit diggings, Kern County, California.

No. 10. Brewer New Gold Pan and Dry Washer. This machine is built of wood and in various sizes from a small hand-operated prospecting machine which can be easily carried about to large sizes suitable for small power-unit operation.

The principal parts are the frame and bellows, and above the bellows the removable riffle board with porous bottom through which the air is forced from below in rapid pulsations. The bottom of the riffle board consists of a light metal screen such as ordinary window screen and a layer of special bolting cloth with cross pieces underneath the riffles supporting it. The frame holds the riffle board at an angle of approximately 30° from the horizontal.

While there is nothing new in principal in this machine, the builder claims special efficiency through careful attention to certain construction details which insure tight joints so that no very fine gold is lost.

Loss of fine gold may easily occur if a machine of this type is carelessly assembled. Instructions for making are furnished to those who prefer to build their own, rather than buy.

No. 11. Burch Gold Concentrator. This machine is now known as the *Reeder Fine Gold Saver,* which see.

No. 12. California Dry Ore Concentrator Company. This company advertises that it has the only dry ore concentrator that is dust proof and fool proof and recovers 95% of values. First cost very low, operating cost more economical than any other. Requires small space. Installations from five tons daily upward. Further particulars may be obtained from the company.

No mention is made of placer operations and it is not known whether the machine is intended to work dry placers or not. It may be a magnetic concentrator.

No. 13. Centrifugal National Concentrator, apparently is designed primarily to handle low-grade complex ores as a circular describing it makes no mention of its use on gold-bearing sands or placer material. The machine is said to be automatic and continuous in operation employing centrifugal force, doing with solids that which centrifugal cream separators accomplish with liquids. It is claimed that this concentrator will save and separate values of microscopic fineness not amenable to recovery by present methods of concentration and that it requires no chemicals or other outside agencies except water in its operation. A unit treating 200 tons of ore per day of 24 hours will occupy 100 square feet of floor space; may be operated by one man per shift and will consume less than 5 horsepower.

No. 14. Centriplus Machine. This machine is described as an improved centrifugal concentrator with continuous discharge. A separator with a continuous concentrate discharge using centrifugal force to increase the specific gravity of metals or nonmetallic matter, so they can be extracted from the pulp or sands.

It is composed of three major parts: The bowl (or stratifier); the spider (that which carries the rings); the housing (forming the body of the machine) carries the bearings on which the bowl and spider revolves, and the stationary launders, which catch the concentrates discharged from the rings.

The bowl is circular in form with a larger diameter at the top than at the bottom, being about 23 inches high, 14 inches wide at the top, and 11 inches wide at the bottom. There are 4 or more slots cut in its side encircling it at different distances from top to bottom.

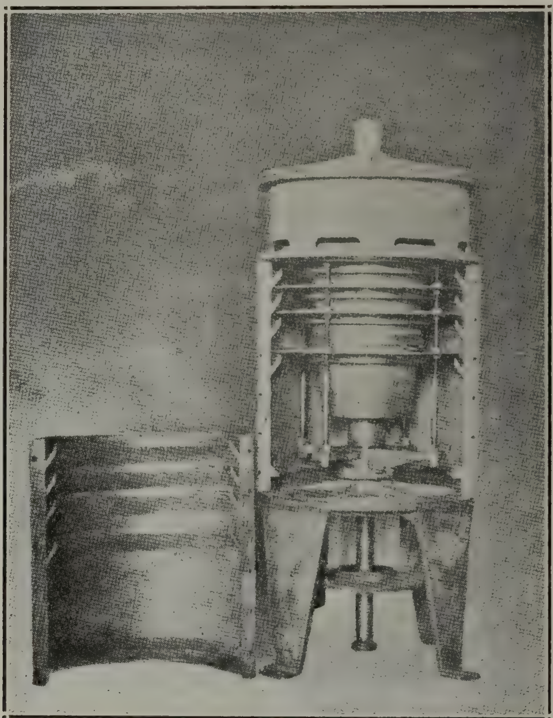
The spider carries the rings, one of which is opposite each slot, in the bowl. They revolve with the bowl, but are independent of the bowl. The concentrates coming through the slots in the bowl are held by the ring. The ring is about 1 inch thick, with one wall vertical and one of greater radius with a discharge angle. The bowl is adjustable up and down in the spider, so that the slot in the side of the bowl (or stratifier) is on one or the other wall of the ring and so controls the discharge of concentrates through the side of machine.

The pulp is fed into the bottom of bowl, or stratifier, where it is thrown against the inner wall by the centrifugal force. As it travels up the wall (owing to its angle) the heavier particles working to the line of greatest motion will be found next to the wall and as they

travel up the side they are caught in the slots where they are held until discharged by the ring.

The concentrates from each ring can be caught separate, as the heavier metals are discharged from the lower rings and a classified concentrate is obtained. The residue, after extraction of the concentrates, travels up and over the top of the bowl as tailings.

A separator of this size will occupy a floor space 4 feet square. It will handle 50 to 60 tons per 24-hour run, from the finest of slime



No. 14. Centriplus Machine.

to heavy sands. There is no pulp too fine nor sands too heavy for this machine.

As the water is used only to move pulp through the machine, its chemical contents have no effect on separation.

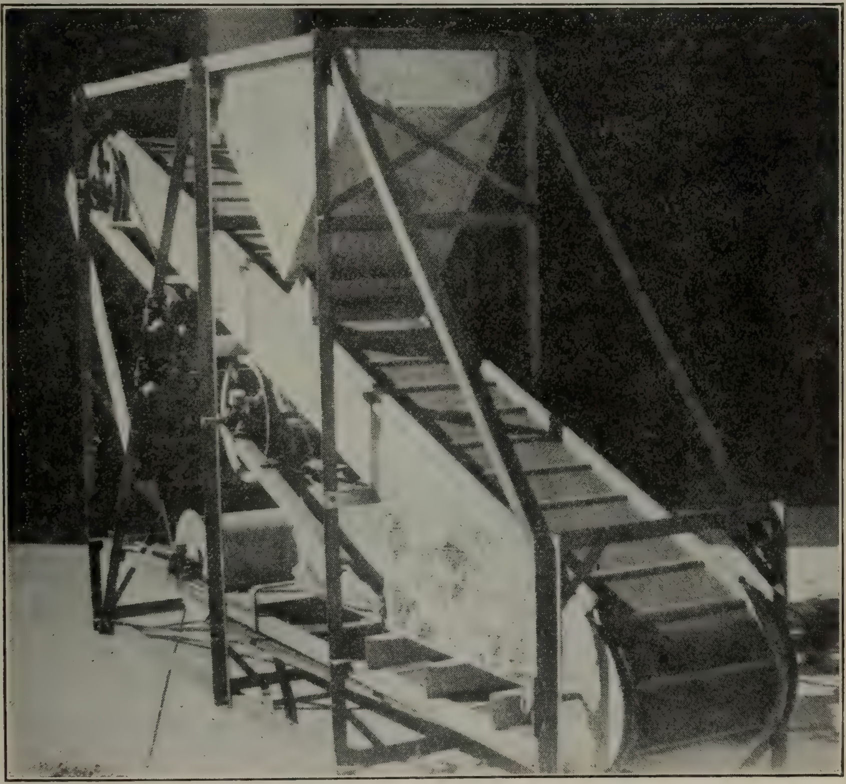
It takes less than 2 horsepower to operate a separator of this size.

No. 15. Chase Concentrator. The Chase concentrator is said to be applicable to placer, hydraulic, dredge and quartz mining enterprises. It is a stationary table, free from all motion therefore requiring no power. Classification and concentration are carried out solely by controlling the action of running water.

No. 16. Cole Dry Separator. According to the manufacturers, their latest machine is designed for both ore or placer, and has a capacity of approximately three yards per hour of placer, or four tons per hour of ore.

The machine is so designed that almost any richness of concentrate can be obtained by slowing down the moving belt. The tailings are discharged from the lower end of the machine while the concentrates are deposited from the head of the machine into a container. It is possible to concentrate as high as sixty to one with this new unit. When the material to be concentrated leaves the hopper it passes down over a moving belt which carries the concentrated material up to the top of the machine; when this material passes under the point of feed the concentrating action is still in full force which in turn throws any gangue over the riffles and leaves the materials as clean as possible; the gangue then travels down the moving board and meets the heads where it is reconcentrated. This action is repeated as long as the heads are passing over the riffle board.

From tests on some ores extractions as high as 89% have been made. This was done on free-milling ore, by grinding it to minus



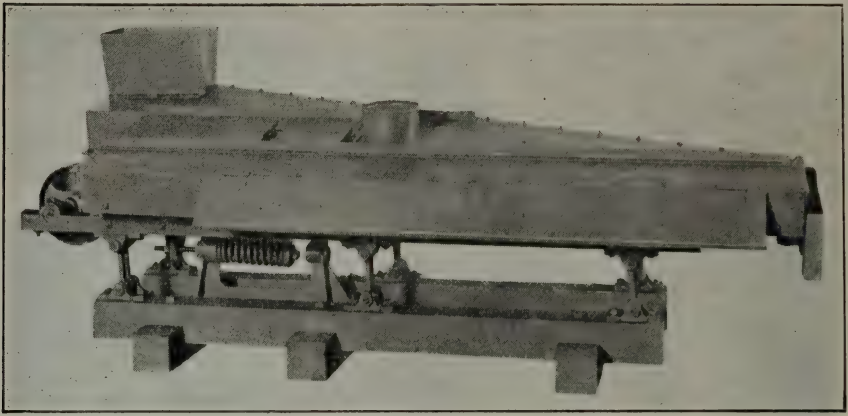
No. 16. Cole Dry Separator.

forty mesh: and with placer, where the gold is free, practically everything can be saved, meaning over 97%.

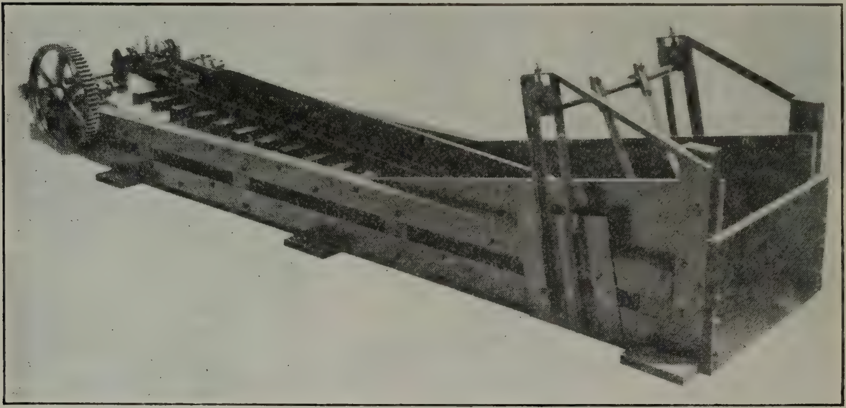
No. 17. Cottrell Pneumatic Portable Dry Washer. This machine is designed solely for dry placer operations and can be easily handled by one man. Fitted with screen and elevator and mounted on skids it makes a light portable unit.

It is manufactured in all sizes with a capacity of from 1 to 25 yards per hour.

The manufacturer states that although of the simplest type yet it is built to withstand the strain to which a machine of this kind is subjected, the best materials being used and all parts made accessible. The riffle board is of perforated corrugated steel and is removable for cleaning purposes.



No. 17. Cottrell Dry Concentrator.



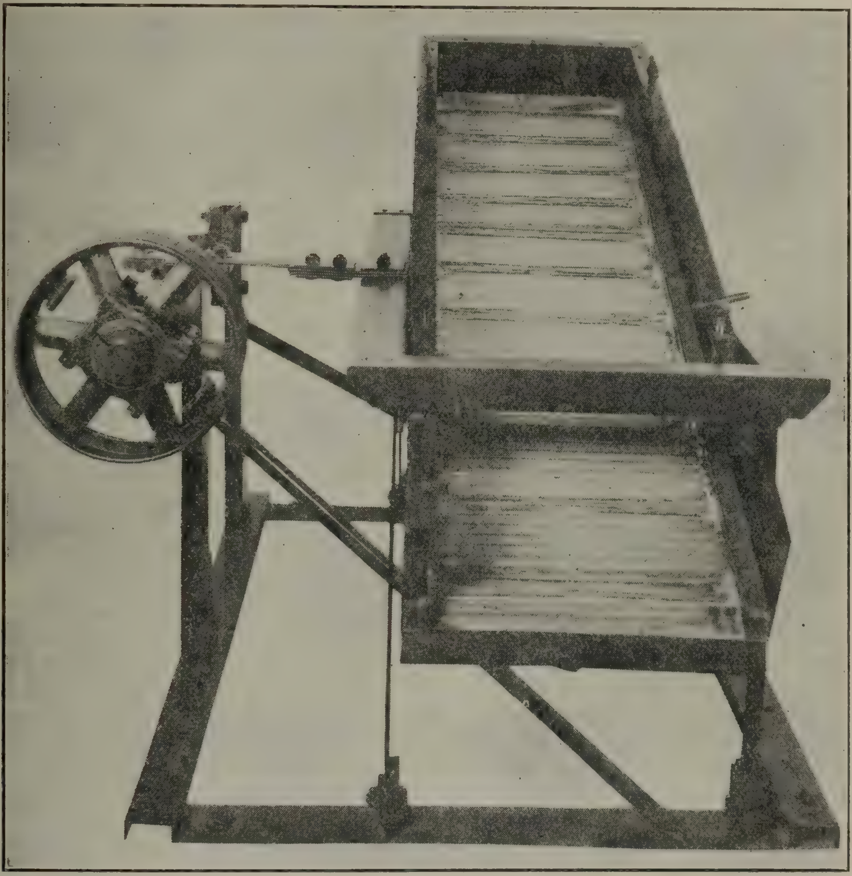
No. 17. Cottrell Wet Placer Machine.

Air is supplied by a constant blower and the machine is given a side motion by means of an eccentric. The air pressure is regulated by a valve and the angle of the riffle board may be adjusted to suit requirements. A screen and cover can also be fitted and the machine may be obtained complete with engine, blower, screen and elevator, or as a separate unit.

This company also manufactures a pneumatic dry concentrator for the concentration of various metallic ores, and in the nonmetallic

field for the separation of crystalline silica from pumice, ash and sulphur from coal, etc.

Wet Machine: The same company manufactures a simple wet machine in which an undershot flow of water cases flotation, the gangue is removed by a mechanical system of rakes and the gold settles down into a specially prepared compartment. A capacity of approximately 50 tons per hour may be handled by the standard 12-foot machine.



No. 17. Cottrell Dry Placer Washer.

No. 18. Crangle Gold Saving Machine. No details are at hand concerning this device. It is thought to be one of simple design, probably home made. Further information will have to be obtained from the builder.

No. 19. Crown Placer Concentrator. Described as a new economical placer mining dry-land dredge. It is claimed to handle yardage economically and save the values. Especially adapted to properties where there is a scarcity of water. Units from 24 cubic yards to 5000 cubic yards capacity per 24 hours.

A prospector's model is also made with a capacity of 1-cubic yard per hour, price complete, f.o.b. Seattle, $350.

No. 20. Cunningham Process, for recovering gold and platinum in river placers. It is stated that in this mining scheme it is proposed to use the river bed itself as a natural sluice, the idea being to lay a series of pipes across the stream on bed rock. These pipes are slotted so that black sand, gold and platinum being carried along the river bottom by the natural current will work through the slots and collect in the pipe just as these minerals collect in natural crevices in the bed-rock. Means are provided for removing the collected material from the pipes. Apparently once installed there would be little work connected with operations.

No. 21. Douglas Manufacturing Company, is said to have a machine on the market which will save 99% of flour gold. Details concerning the device will have to be obtained from the makers.

No. 22. Dry Extractor for Gold, and all metals, faster and better than with water, according to advertising matter. Capacity 100 to 3000 tons a day. Machine demonstrated in San Leandro.

No. 23. Dugan Dry Concentrator. Probably the same machine as that described under *Placer Gold Mining Machine Equipment,* which see.

No. 24. Dunham Ground Sluicing Apparatus. U. S. Patent No. 1380642. According to the patent specifications, "The invention relates to improvements in apparatus for sluicing placer ground, and the object of the invention is to provide an apparatus the use of which will increase the efficiency of the water used in hydraulicking such ground and reduce the number of men required to work it, thus rendering it possible to develop properties of this nature at a profit where at the present time it would not pay to install a hydraulic plant."

The manner in which the apparatus operates may be briefly described as follows: The ground having been sloped to the proper rake the apparatus is moved into position with the rear end of the channel abutting the forward end of the first sluice box. The framework is then lowered until the fingers are in position to scrape the surface of the ground to be operated on, after which the chains are set in motion, whereupon the fingers will loosen up both the ground and any boulders therein, so that the water directed thereon at the same time will readily wash the loosened ground into the sluiceway and carry it along into the sluice boxes, the entire operation being effected mechanically and without the use of manual labor for loosening the ground, thus enabling a greater area to be washed in less time and with less expense than at the present time.

No. 25. Edison Dry Process, for separation of gold from gravel. It should be of interest to the inventors of gold-saving machines and they may feel complimented to know that the late Thomas A. Edison is numbered among them. About 1897 Edison took up the problem of finding a process which would save gold in a large placer deposit situated in the arid regions of New Mexico.

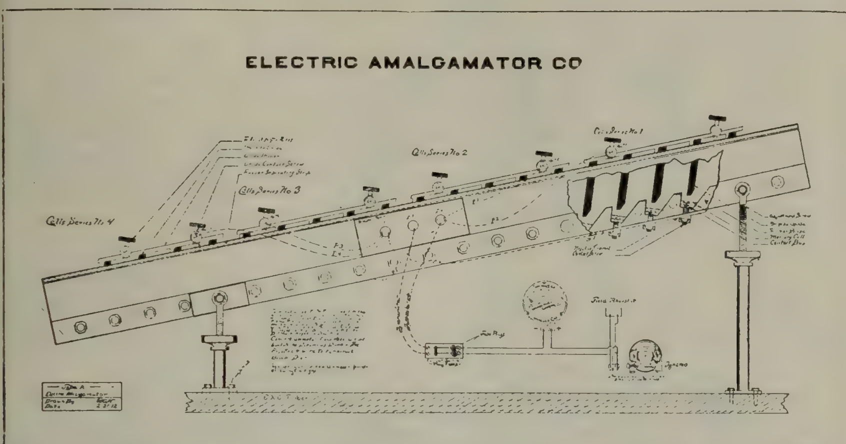
An account of his work and a cut of the Edison Dry Placer Machine, by Cloyd M. Chapman was published in the Engineering and Mining Journal, May 9, 1903.

No. 26. Ehorn Placer Machine. A machine for saving fine gold said to have given good results was operated on Little Butte Creek, 9 miles southeast of Chico by Cap. Ehorn. Its construction is not known. It may be the Giffen machine referred to later or a similar apparatus.

No. 27. Electric Amalgamator Company manufactures a patented electric amalgamator which appears from a circular to be applicable mainly to milling practice as no mention is made of its adaptability to placer operations.

No. 28. Ellis Automatic Electro-Chemical Gravity Method. These notes are taken from a circular of unknown date.

The Ellis Automatic Electro Chemical Gravity Method for separating minerals from ore is the only actually continuous and automatic chemical process, for separating minerals from ore, in practical use, and the cost is only a few cents a ton more than the ordinary amalgamation process. The leaching is commenced in the mill battery and



No. 27. Electric Amalgamator Company's Apparatus.

continued down a launder provided with riffles for aerating the pulp and solution. After passing through a launder of sufficient length, say 50 to 500 feet, the pulp and solution runs through an electric precipitator and amalgamator that precipitates the minerals in solution and forces the same by gravity in contact with amalgamated copper plates and riffles, amalgamates the precipitates and free gold and silver. The pulp and solution after extracting the values, passes into dumping tailing tanks, where the coarse tailings are retained, with the solution running through a filter bottom and overflow into settling tanks, from where the solution, after filtering or settling, passes to a sump and is pumped back to the mill to be used over again. Two tailing tanks are used for the coarse tailings for each precipitator and are dumped alternately, one draining, while the other is filling, or they may be made to dump automatically.

The idea of this process is not to dissolve the gold as much as possible, as with all other chemical processes, but to dissolve it as little as necessary, only enough to free it and clean it for good amalgamation, which is also assisted by the electric current in passing through

the machine. The amalgamated copper plates in the machine are at all times kept in best possible condition for amalgamation by the solution of cyanide or other chemical combination used and the electric current by which the mineral in solution is precipitated. The precipitant being an electric current generated by electric batteries, not depending on the chemical action in the precipitator, the precipitation will continue regardless of the different minerals and bases in the ore as long as there is no insulating coating on the anode.

In this process the cyanide will act more on the ore in a few seconds with the thorough aeration of pulp and solution in passing down the launder, being continuously checked and violently agitated by the riffles, than it would with hours of leaching in tanks. In the precipitator, the pulp and solution are forced in contact with the anodes and cathods alternately by pressure of gravity, both being amalgamated copper plates and only a fraction of an inch from each other, thereby giving very intense electric action on a small amount of ore a short time, and forcing the precipitates and mineral in contact with the amalgamated surfaces.

The leaching being only partial and with the weak solution not having time to act much on the bases, very little cyanide is used, as the electric current regenerates greatest portion of the small amount used. With this process taking the crushed ore direct from the mill, it ought to be cyanided at a cost of from 5 to 15 cents a ton exclusive of royalty. In working old tailings the cost of taking the pulp to the receiving hopper must be added.

Present address, very doubtful.

No. 29. Elms Machine. A gold saving machine said to be good on fine gold. This may be one of the machines described under another name or a different device. Details will have to be obtained from the owner.

No. 30. Elsol Dry Concentrating System. Various types of Dry Concentrators and Dry Washers have been on the market for years and thousands of dollars have been expended on experimentation and development work in dry concentration, with the result that varying degrees of success have been attained.

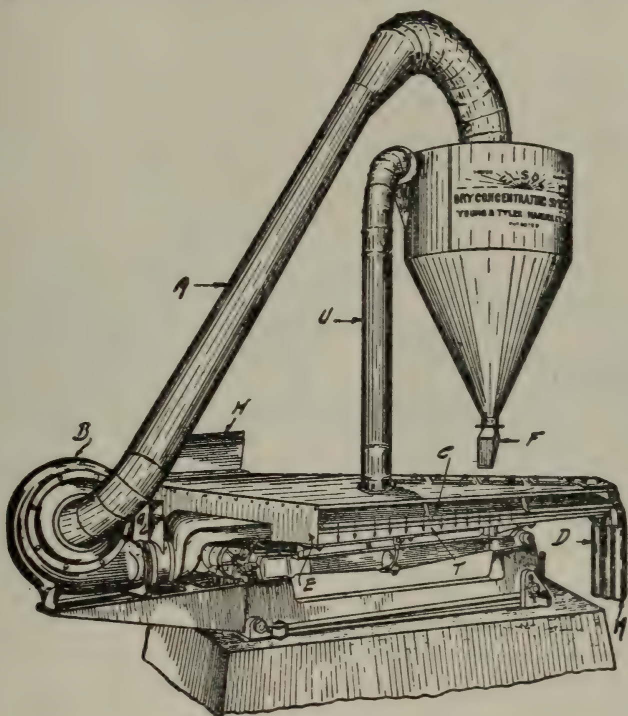
The appearance of the 'Elsol' marks a new epoch in dry concentration since it combines the successful features resulting from years of experience, giving a machine having positive working qualities coupled with efficiency and simplicity. In other words, it gets both the fine and coarse values with little classification, and at the same time does so in the simplest possible way, with no complication, few wearing parts, low repair costs, and with a minimum expenditure of power.

Quite often large percentages of fine values are lost, due to their being blown from the table by the air system. The 'Elsol System' allows nothing to escape except unreleased values going to tailings. By proper crushing this percentage of unreleased values may be reduced to a very small amount. The peculiar formation of the riffles of the 'Elsol' Concentrator securely holds both fine and coarse values once they are caught therein. Any small amount of very fine values rising from the table are taken up by the air system and caught in the dust collector forming a part of the 'system.'

In the 'Elsol System' the table movement is accomplished by means of a peculiarly arranged set of eccentrics which together with a relatively high rotation gives the rapid progressive movement of the material. There are no springs and no lost motion; the action is positive and requires a minimum of power.

The riffles of the 'Elsol' Concentrator are of an obtuse angled V-shape with one side—the front or bottom side—longer than the other, and when in its working position a cross-section presents an appearance similar to that of the lip of an ordinary gold pan when being used by an expert panner.

At the upper or feed end of the table these riffles are of comparatively large cross-section and gradually taper down to a small cross-



No. 30. Elsol Dry Concentrating System.

section at the concentrate-discharge end. The object of this is twofold: It gives a greater longitudinal angle to the upper riffles, besides reducing the capacity per unit length of riffle as the discharge end is approached.

The greater longitudinal angle has the effect of holding the values more securely once they have been caught, since the riffle cuts more sharply across the line of travel of the tale movement. The reduction of cross-section has the positive effect of eliminating the gangue matter which may be riding near the top of the riffle.

The bottom side of all riffles are perforated with a nozzle-like perforation placed at such angle as to not only give the lifting effect on the material (thus allowing the values having the higher specific gravity

to settle to the bottom) but also to aid in a more rapid advance of the material along the riffles.

Standard sizes, with average capacities:

	Capacity, tons per hour Quartz	Placer	Power required	Weight
No. 2	2–3	8–10	2 h.p.	1800 lbs.
No. 3	4–5	20–25	3 h.p.	2000 lbs.

The concentrator is all metal. The riffle board is in one piece, corrugated and perforated by special dies. The high speed positive movement is set in dust proof ball bearings. These parts are mounted on a cast iron base, assuring perfect alignment under all conditions.

The dust, one big objection to dry concentration, is no objection in the 'Elsol' for it automatically cares for its own dust by its self-contained dust system.

No classification is necessary, the peculiar shape of the riffles automatically taking care of this feature.

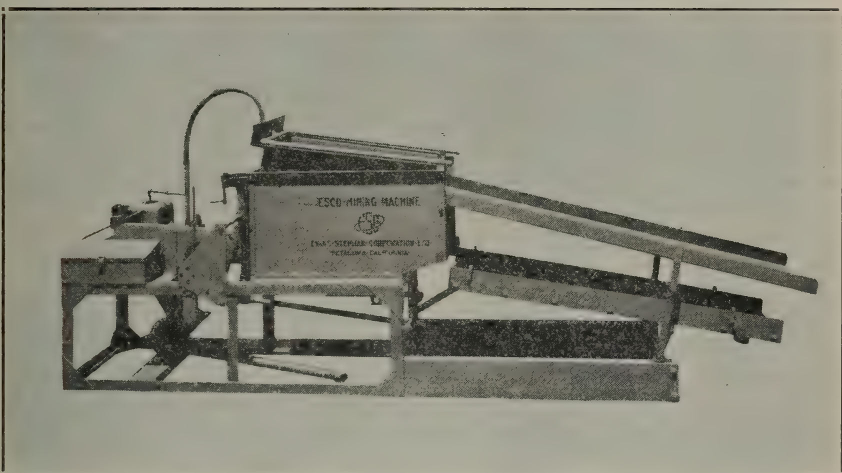
The operation of the Elsol Dry Concentrator is readily understood by referring to cut. A specially constructed single piece metal surface 'C,' over which the crushed ore is made to travel, forms one of the principal features necessary for efficient concentration. This surface is formed by special dies into V-shaped corrugations or riffles tapering from a relatively larger cross-section at the feed end 'H' to small cross-section at the concentrate discharge end 'D.' One side, the front or bottom side of these corrugations, is perforated with tiny nozzle-like openings through which air is forced from air-chamber 'E' on which the surface is mounted. The air shooting through these tiny perforations together with a rapid table movement quickly causes stratification of the material. Once stratified, the progressive movement and reduction of cross-section of corrugations continually causes an elimination of the top strata of the material in each riffle until the discharge end is reached, where the gangue matter has practically all been eliminated. Whether the concentrate is fine or coarse, provided it is caught in the valley of the riffles, it can not escape, as the movement continually crowds the heavy particles into the valley, and no air comes in contact with the particles thus reaching the bottom. A certain proportion of very fine material, due to air and agitation, will rise from the table surface. This is drawn up through the uptake 'U' and collects and discharges at 'F.' The return air circuit 'A' connects with the exhauster-blower 'B,' which serves the double purpose of supplying air to the air chamber and collecting the fine simultaneously. A blast-gate, plainly seen in the illustration, between the blower and air-chamber, properly regulates the air supply.

These machines are operating in the field with a success heretofore unknown to dry concentration. The following ores have been treated with uniform success: lead-zinc, lead-silver, copper, tin, gold, iron, antimony (both oxide and sulphide), tungsten, wulfenite, chrome, manganese.

While certain classes of ores respond to concentration in much the same way it must be remembered that the fundamental principles underlying any system of gravity concentration are based on a difference in specific gravity between the materials to be separated. Generally speaking, the greater this difference the more clearly defined

becomes the line of stratification, the cleaner the concentrate and the more perfect saving. There are other conditions, however, that modify this statement to considerable extent, such as size, shape and density of the material to be separated. It is these 'other conditions' along with the fact that the same kinds of ores in different localities have different characteristics, that makes it difficult to predict just what savings can be made on a given ore, even though certain definite results have previously been obtained on the same kind of ore.

No. 31. Esco Mining Machine, Type A, described as follows: 13 feet 6 inches long, 2 feet 6 inches wide, 5 feet high; weight 1350 pounds; requires $1\frac{1}{2}$-h.p. gasoline engine (about 1 gal. gas per 8 hours); one-inch centrifugal pump; Stephan Concentrator, capacity from 40 to 60 yards per 8-hour day, depending on material. One man can operate. Balance of operating cost governed by local conditions.



No. 31. Esco Mining Machine, Type A.

The manufacturers state that the Esco Mining Machine is a complete placer mining machine which requires no technical training to operate. It is unequaled in performance, simplicity, and the recovery of metals. It will save precious metals to a very fine degree from placer deposits or decomposed quartz. Each machine is equipped with a Stephan Concentrator.

Excellent results may be obtained in separating free metals from milled ore if run over our specially devised concentrators, where material is 30 or 40 mesh, but no finer. Without technical processes such as amalgamation, cyanide, etc., we will with our concentrator make a greater recovery of free metals than any other known method.

The Esco Mining Machine was devised for the entire mining industry, and particularly for the concentration and saving of precious metals from placer deposits. It will handle more gravel for its size, with less water and a smaller loss of gold, etc., than any device at present in operation, and without the expensive process of amalgamation being resorted to. Larger size machines than those specified will be made as the industry demands.

The concentrator will save flour gold many times finer than it is possible to save with the pan, yet so far as is known this has always been considered impracticable without using the amalgamation method.

In operating the machine the sand or gravel, together with a deluge of water, is put into the hopper or separating unit (special features of which are patented or have patents pending), which is agitated back and forth, throws off the large rocks, etc., and washes the fine particles through a screen onto the concentrator. This concentrator is a long, narrow, sluice-like structure, adjustable as to its slant toward its discharge end, which has a double action agitation upward and backward, with a kick-like action resembling that given the pan by one's hands. The floor of the concentrator is provided with a longitudinal central groove leading to a sump-outlet for clean-up purposes. Extending laterally from the central groove are other grooves arranged at just the proper angle necessary to hold the particles of gold, etc. Below the sump is a low dam over which the waste materials are washed. Above the floor of the concentrator is fitted a grate consisting of cross-bars held a fraction of an inch above the board, causing an under-current which keeps the silt and light materials in suspension, thereby avoiding packing of the grooves, and at the same time drowning light particles of precious metals such as leaf gold, which would otherwise float off, and allowing metal particles to settle in the grooves and remain there.

By properly regulating the adjustments on the hopper and concentrator, the operator will soon learn just how much material he can retain and just how often it is necessary to make a clean-up. A clean-up can be made in a few seconds without stopping the engine, but in some materials this may not be necessary more than once or twice a day. The concentrator can be lifted off and carried into the cabin if desired, and cleaned up after dark. Another interesting feature of our concentrator is that you can always see what you are saving by merely stopping the action for a short time.

No claim is made to save all the valuables from every kind of material, but when the gold is free it will lose not over 1 per cent in most cases.

The concentrator will save all precious metals of appreciable specific gravity, rusty gold, sulphides containing gold, platinum and iridium, all of which will not amalgamate, and will also save diamonds, rubies, etc.

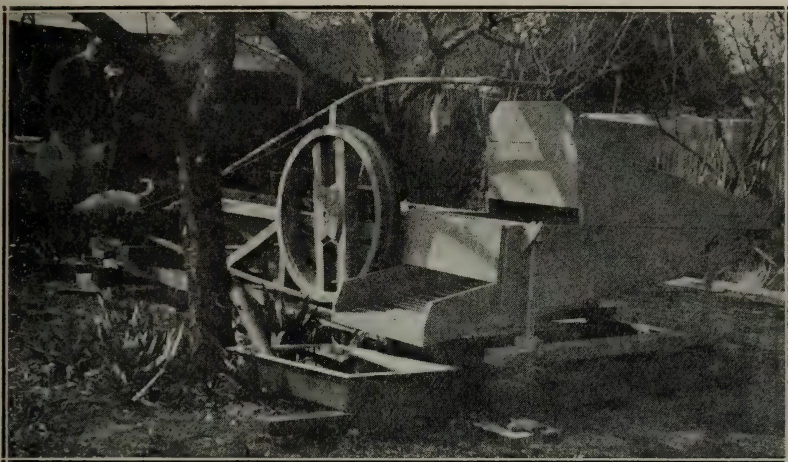
By a little ingenuity a large part of the water used can be saved and run back into your tank and used over again. This fact makes the machine valuable where water is not plentiful.

Remember, this machine uses very little water, does away with other much more expensive equipment, is easy to handle and move about, and is very economical to operate.

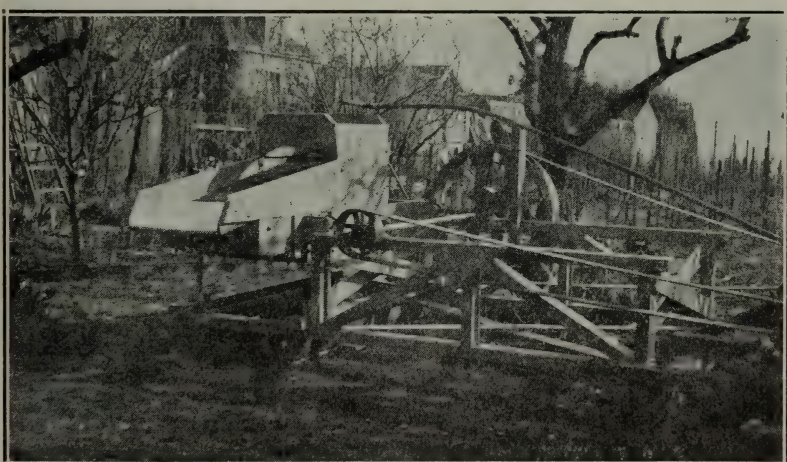
No. 32. Fabriform Amalgamator. After testing various amalgamation processes a special amalgamator by this name was reported recently installed at the Good Hope Mine, Riverside County, to rework the dump. One unit is expected to handle from 40 to 50 tons per day. No description of this apparatus is available to the writer.

No. 33. Ferguson Forced Feed Amalgamator and Concentrator. The Ferguson machine is said to be based on the principle of revolving

paddles and a washing process which deposits the finest particles of metal into a concentrate box, where it is drawn off with a special amalgam. Several of these machines are said to have been installed and operated in Mariposa and Humboldt counties. They are made with capacities of 25 to 500 yards per day. A recovery of 98.9% is claimed.



No. 34. Fields Portable Power-driven Rocker.



No. 34. Fields Portable Power-driven Rocker.

No. 34. Fields Portable Power-driven Double-rocker. This machine, of the simple rocker type, is constructed so that it may be readily converted into a trailer and thus easily moved from place to place by automobile. It was constructed primarily for the owner's own use, but possibly will be built on order for others.

No. 35. Dr. Roy Fitzgerald Black Sand Process. A secret formula (So-Zo-Zone) for amalgamating and recovering gold from black

sand. Alleged fraudulent claims in connection with the exploitation of this process has resulted in Mr. Fitzgerald being brought into court to answer.

No. 36. G.-B. Portable Placer Machine. The G.-B. Portable Placer Machine fills a gap that has always existed. It is something the prospector has dreamed of but never found until now. It is a portable, self-contained water, gold saving placer machine which can be operated by one man.

It stands but 54″ high, 79″ long, is 24″ wide, weighs only 140 lbs., and the motor weighs but 90 lbs. It can be knocked down in a few minutes, packed into the water tank (exclusive of motor) and placed on the rear seat of an automobile, or it can be carried (without motor) on one burro.

It is quickly set up at any spot you wish. It enables the prospector or engineer to sample a gravel bank whenever he wishes. If the prospecting happens to be in a desert country, it is only necessary to carry a small amount of water for a day's operation, because the machine recovers and reuses all the water necessary except that lost in the tailings. Carrying from 10 to 25 gals. of water permits the operation of the machine for some time.

No. 34. Hand model for prospecting.

The sand or gravel is shoveled into the receptacle (4) and is washed down the launder. The coarse rocks are thrown out at the end of launder; the gold-bearing sands are washed down through the grill (5) and flow back on to the riffle box (6). Mercury can be used in the riffles, if desired, permitting recovery by amalgamation where preferred. Free gold and black sands are recovered in the riffles, which receive a panning motion from an eccentric shaft. The riffle box is easily and quickly cleaned as it is merely lifted out of the cradle arms. Consequently the gold or black sands retained by the riffles can be washed into a pan.

(1) One-half h.p. gasoline motor, ample power; (2) water pump (not shown in photo), which draws water from steel tank, delivering it

to launder through hose (3); washes sand which has been placed in receptacle (4), down the launder where coarse gravel and rocks are ejected at grill (5), fine sand and gold washed through the grill and back down lower launder to riffle box (6) where sands are washed by panning motion of riffle box; conveyor (7) carries tailings out, allowing

No. 36. G.-B. Portable Placer Machine.

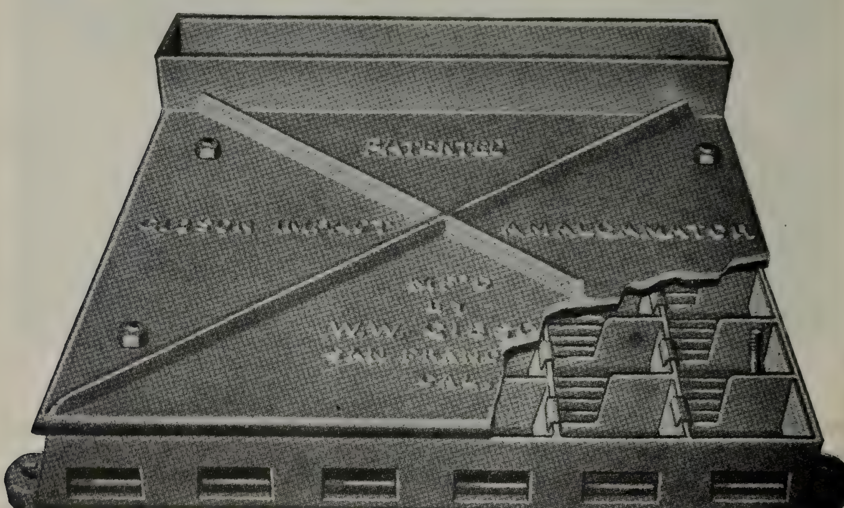
water to drain back into tank. Riffle box (6) can be lifted out and contents washed into pan.

Within the galvanized tank there operates a sand dewatering conveyor, together with a settling basin. The bottom of the tank acts as a water reservoir. From this reservoir the centrifugal pump returns the

water to the feed from which point it again is delivered through the launders. Excess water drains back to the reservoir and the dewatered sands are discharged from the box by the sand drag.

The G.-B. Portable Placer Machine has a capacity of from three-fourths to one ton of unscreened sand per hour, eight tons being the average per shift, from recent records.

No.36. G.-B. Machine, side view.



No. 37. Gibson Impact Amalgamator.

No. 37. Gibson Impact Amalgamator, is a patented amalgamator made of aluminum. The No. 1 of 30-ton capacity has 42 compartments, 216 riffles and 12 feet in length of silvered plate. The No. 2 or 125-ton amalgamator has 99 compartments, 1000 riffles and 66 feet in length of silvered plate. Each compartment has a small silvered copper plate standing on edge. The bottom of each compartment has a grooved floor which leads the heavy particles of gold and amalgam towards the plate.

In milling practice it is customary to attach the amalgamator to a concentrating table, the table feed passing through the amalgamator before entering the table distribution-box. For dredges or placer mines a special head-motion is furnished which gives the amalgamator the same motion that a concentrating table has. It is this motion which causes the impact wave.

Rusty and tarnished gold is subject to a continuous backward and forward sand scouring and is finally brightened so that it adheres to

No. 38. Giffen Placer Machine. General appearance of plant.

the upright amalgam plates. It is also said to be impossible for fine gold to float through the Gibson amalgamator as the cover is provided with a rubber gasket which makes it water-tight and all the feed has to pass under water from compartment to compartment.

No. 38. Giffen Placer Machine. This machine which is adapted to localities where water is scarce is described by Haley[1] as follows: The machine consists of either a shaking or stationary hopper and water feed under pressure in the hopper, a shaking table with a side motion, set at a pitch averaging about 3 inches to the foot, and a type of riffle known as the Giffen riffle. The inventor claims that near Manhattan, Nevada, he could wash 40 yards of dry gravel with a supply of 9 gallons of water per minute, for 6 hours a day, the consumption being 80 gallons per yard. By the use of a trommel, the amount of gravel washed is materially increased. The dirt is fed into the hopper by an elevator.

[1] Haley, Chas. S., Gold Placers of California, State Mining Bureau, Bulletin No. 92, 1923, p. 68.

As the dirt dumps and spreads out, it is met by the water discharge, which thus gives a fair washing before the gravel reaches the table. The upper 18 inches of the table has another riffle, thus allowing the dirt to spread and cross the table in a thin wide stream, which causes a very fair degree of concentration to occur before the first riffle is reached. Four sections of riffle each 16 inches long were used, although it was only necessary to clean the upper one daily, the second every other day and the other two once a week. Where water is scarce, it is pumped back and used over and over. The plant can be moved and put in operation in less than one-half a day. The inventor claims that under ordinary circumstances the ground can be delivered, washed, and the tailings cleared away, so far as necessary, for 30 to 35 cents per yard.

No. 38. View of Giffen Placer Machine. Taken when washing 24 yards per hour, at Rocklin, California.

No. 39. Gold Finder. A portable dry gravel washer. Price $50. No other details are at hand except the address of the maker.

No. 40. Gravitational and Centrifugal Gold Saver. This machine is manufactured in Portland, Ore. It consists of a large round disc or pan one inch thick and four feet in diameter with a round plane or space in the center bottom of the disc a foot and one-half in diameter. There is a break in the plane and a gradual rise toward the outer rim or edge of the disc. This slope upward from break in the plane is at an average uniform rate of three inches to the foot of travel toward the outer edge. A series of round grooves or rings are cut in, or machined out, of the sloping surface of the disc so that each groove makes a complete circle. There are twenty-two of these rings or riffles, one above the other, each separated from the other by a wall one-fourth of an inch in thickness and three-eighths of an inch in height; each wall also makes a complete circle. The disc is mounted on a shaft and pedestal so it is exactly level. Then the rings or grooves are filled about one-half full of liquid mercury. Gold bearing sand is

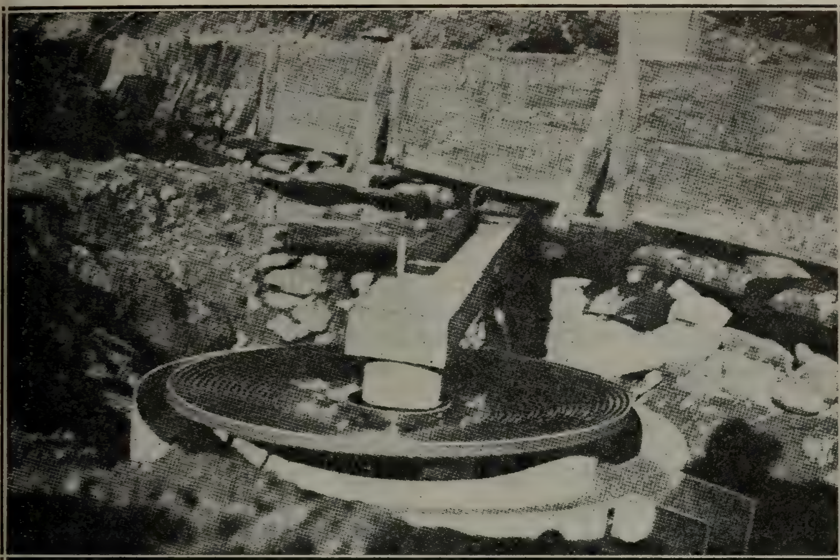


Figure I.

No. 40. Gravitational and Centrifugal Gold Saver.

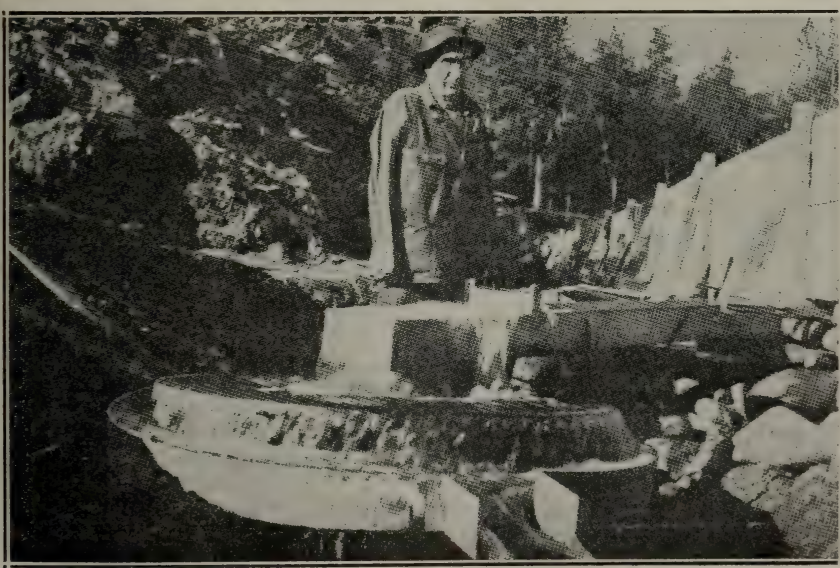


Figure II.

No. 40. Gravitational and Centrifugal Gold Saver.

mixed with a stream of water and is poured onto the disc or pan while it slowly rotates.

This rotation has a tendency to do two things. (1) It causes the sand and water to circle from the bottom toward the outer rim or edge of the disc. (2) It has by virtue of this tendency the effect of compounding the force of gravity, thus causing the gold to sink deep into the grooves where it contacts the mercury for which it has an affinity, while the dirt and common sand and gravel are washed over the rim of the disc. This operation is kept up until the mercury becomes saturated with the precious metal, and then it is drained off the disc and the mercury separated by the usual means.

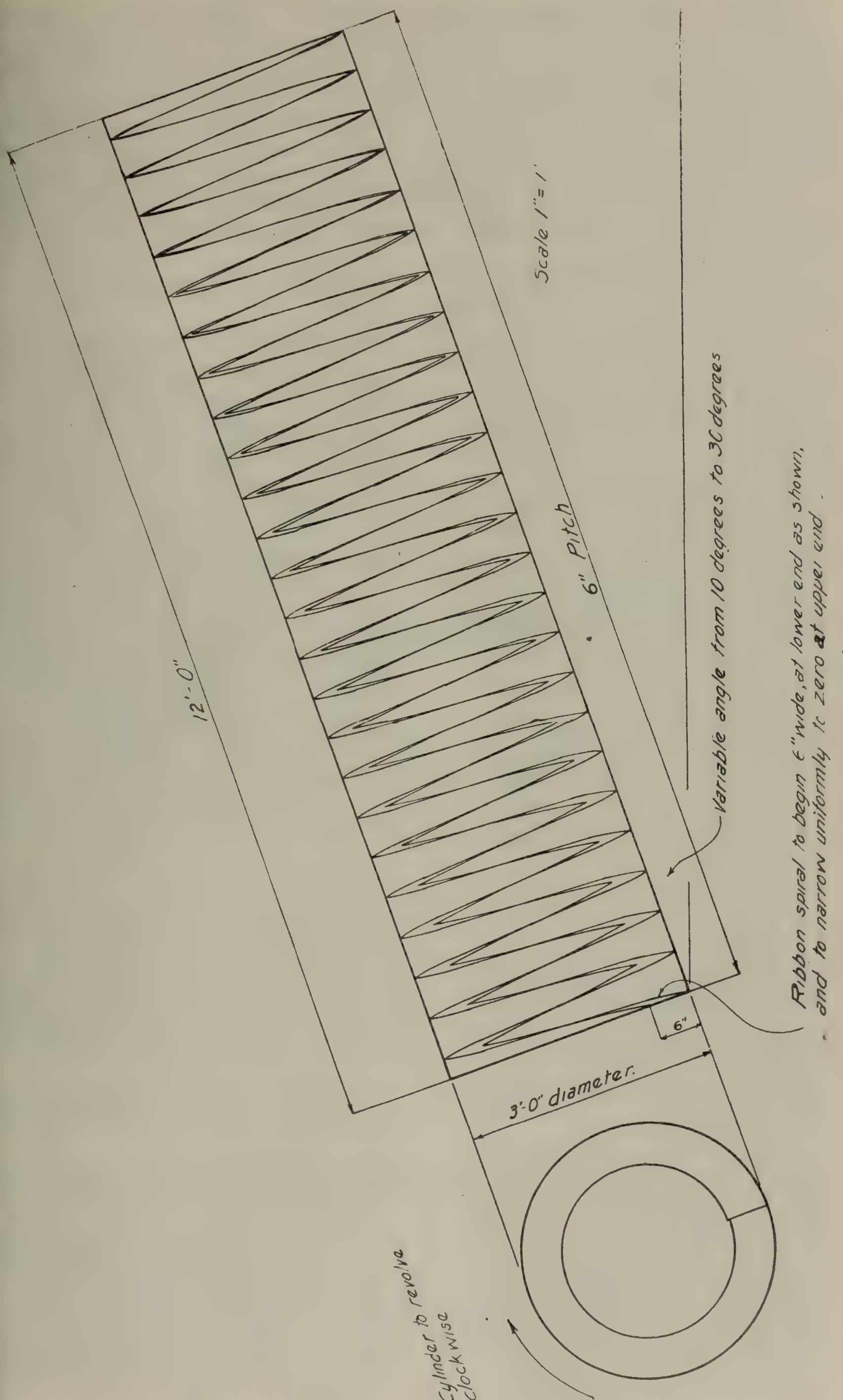
Figure II shows the disc in actual operation on a placer property located on the Rogue River in Southern Oregon. This picture shows the disc over which the gold-bearing sand is carried by water from the sluice box. The disc rotates at the rate of about three or four hundred feet of peripheral travel per minute. The water combined with the centrifugal action caused by the rotating disc, carries all the tailings over the outer edge of the disc, while all of the gold, or other precious metals is caught in the rings or grooves on the face of the disc. Free gold in this operation naturally combines with mercury as set forth in Figure I. Gold, being heavier than other materials, naturally travels on the bottom of the sluice box. When the underflow is taken from the bottom of the sluice box through a screen and directed over the disc it naturally carries with it all the precious metal. This is directed over the disc and is captured in grooves by the mercury as suggested in Figure II, while the large stream of water carries away all of the tailings.

This gold saving machine is being built in two sizes, the rings or grooves being the same width and depth in either size machine. The disc for No. 1 machine is two feet in diameter and weighs about one hundred pounds. It is made of cast iron. Its capacity depends almost entirely on the amount of water available for the operation. In other words, if there is only enough water to wash ten yards that will be the limit of the operation; if there is enough water to wash one hundred yards or more, the two-foot disc will take care of it.

In an operation of this kind the undercurrent from the sluice box should be drawn through a screen not coarser than one-eighth of an inch mesh.

Size No. 2, which is the size from which the Figures I and II were made, weighs 610 lbs., is four feet in diameter and contains twenty-two riffles. It is believed by our engineers that this size will take care of any amount of yardage, sand and gravel, that the water capacity will properly break down and wash. It will handle up to five hundred or even seven hundred yards, depending upon the physical conditions.

For operations where the water supply is limited and water must be conserved, the inventors have prepared a rotary screen in which to wash the gravel. This screen is so constructed that the fine gold is washed through the revolving screen and carried on to the disc by the same means indicated in Figure II, while the coarse gold is caught in the riffles. The water, after performing its duty on the disc, may be caught in a settling tank and pumped back through the screen again if the water supply is meager enough to require such care.


Scale 1" = 1'
12'-0"
6" Pitch
Variable angle from 10 degrees to 30 degrees
Ribbon spiral to begin 6" wide, at lower end as shown,
and to narrow uniformly to zero at upper end.
6"
3'-0" diameter.
Cylinder to revolve
clockwise

The concentric rings or grooves shown in Figure I are intended to be filled about one-third full of liquid mercury. The experience of the inventors and engineers to date indicates that the first six rings or grooves from the center toward the rim catch all the values, so it is believed it will be unnecessary to fill the rings on the outer edge of the disc. Twenty or thirty pounds of mercury are sufficient for the two foot discs, and fifty or sixty pounds are ample for the four-foot disc.

One of the interesting discoveries in connection with this invention is that mercury is never lost or wasted as long as the disc is intelligently operated.

Another interesting discovery is that coarse gold may be reclaimed and saved without the use of mercury.

No. 41. Hammond Dry or Wet Placer Machine. This apparatus consists of a metal cylinder or tube open at both ends. Welded inside of this is a ribbon spiral. On a cylinder 12′-0″ long by 3′-0″ in diameter the spiral is 6″ wide at the lower end and tapers uniformly to zero at the upper end. It is wound on a 6″ pitch. Smaller prospecting sizes can be made in proportion. The cylinder is mounted on rollers and is set at a variable angle from the horizontal, usually 10° to 30°. It is revolved by means of a belt or gearing. The feed hopper is located at the upper end and the feed is introduced about ⅓ way from the top. As the cylinder is revolved clockwise (looking up) the material is rolled along and tumbled over the spiral ribbon. The gold or other heavy mineral remains in the bottom of the spiral trough and is gradually carried up and out the upper end in a thin fine stream. The lighter material passes over the spiral ribbon and falls out the lower end. It is claimed that the machine will work equally well on dry material or in water. The inventor states that a medium size machine can be built for $250. A saving of 90–100% is claimed.

No. 42. Hancock Chemical Process. This chemical process is said to extract 100% of gold and platinum from black sand in 24 hours by acid treatment.

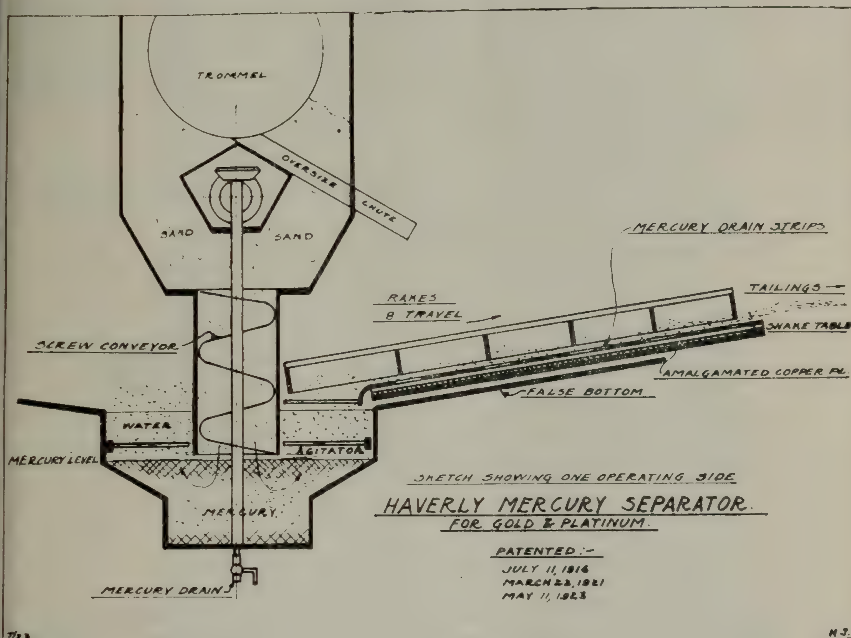
No. 43. Hanssen Process. This process and machine is controlled by a Seattle Company. It is said to have proved quite successful in recovering gold from black sand on the beach of Graham Island, British Columbia. A machine has been set up at Bandon, Ore., and a working model was placed on exhibit in Crescent City last year by the inventors. Further details in regard to it will have to be obtained from the manufacturers.

No. 44. Hart Dry Washer. A home-made dry-wash gold saver built in Fallon, Nevada.

No. 45. Haverly Mercury Separator, for gold and platinum. This machine is patented and it has been built and used with reported success. It takes very little water to operate so may be used in arid regions. The Haverly machine does not depend entirely on amalgamation for extracting but also utilizes gravity. The entire pulp or feed is forced below the mercury surface, the lighter material rising and being removed and the heavier particles, gold and platinum settle to the bottom of the mercury bowl. It is claimed that it will save the finest particles and leafy gold ordinarily carried off by water.

The sketch plainly shows the method of operation and the principles involved. The apparatus consists of a trommel for removing coarse material, a sand hopper from which a screw conveyor draws the fines and forces them below the mercury surface in the bowl beneath. The surface of the mercury is covered with water which is kept in agitation and mechanical rakes are provided for removing the tailing. A shaking table with amalgamated copper plate is placed below the rakes to recover any escaping gold or quicksilver.

This machine is adaptable to both placer and mill work.



No. 45. Haverly Mercury Separator.

No. 46. Homewood Fine-Gold Placer Machine. No details are known concerning this machine but they can probably be obtained from the originator.

No. 47. Hubbell Placer Gravel Machine. Mr. Hubbell states that he has a company manufacturing a machine of the placer type for him. No description of this apparatus is at hand.

No. 48. Hudson Prospector. A placer mining machine or dry-land dredge that excavates, hoists, screens and separates all values from alluvial material wet or dry. A 5-yard per hour complete unit working on gravel running $2 per yard at Randsburg, Kern County, with water costing $1.50 per 1000 gallons was reported by the user as having apparently solved his desert placer problem.

The company states that they will give royalties for workable ground and operate themselves; or take royalties for use of the machines, and give terms.

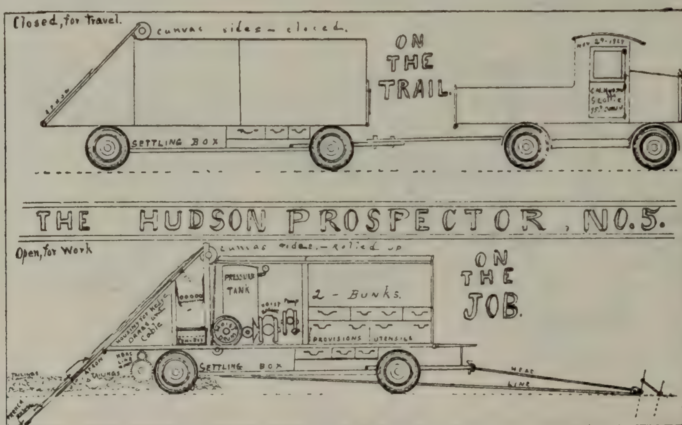
No. 49. Huelsdonk Gold and Platinum Separator. The Huelsdonk machine has been developed over a period of 15 years during

which time it has been used to a considerable extent in the treatment of placer sands and gravels for the extraction of gold and platinum with very satisfactory results.

It was first known as the Huelsdonk submerged table concentrator and had been successfully used for four years by the La Grange Dredging Company in recovering platinum, gold, amalgam and mercury from black sand concentrates, when first described by Logan[1] as follows:

"The concentrator works under still water in a box or trough which is 16 feet long, one foot wide inside, and about one foot deep, being made from 2-inch planks. A small gas engine mounted on the sluice furnishes power for shaking the screen and the concentrator, and for pumping water. The shaking motion is given by an eccentric with ⅜-inch travel. The screen moves on a single bolt support on each side, and the power is applied against springs. From the screen the sand and water pass on to an apron which extends one-half the length of the sluice and is perforated at regular intervals so as to distribute the sand along the table proper. This apron and the table are bolted together and are shaken at the rate of 180 r. p. m. They weigh 600 pounds, and the heaviest part is the engine. Two men are required to run the outfit where hand shoveling is done."

Various modifications have been made since the above was written to meet varying conditions. The machine as recently installed (1928)



No. 48. The Hudson Prospector.

at the property of the Dominion Mines and Development Company in Plumas County is shown by the accompanying photo and is described by Averill[2] as follows:

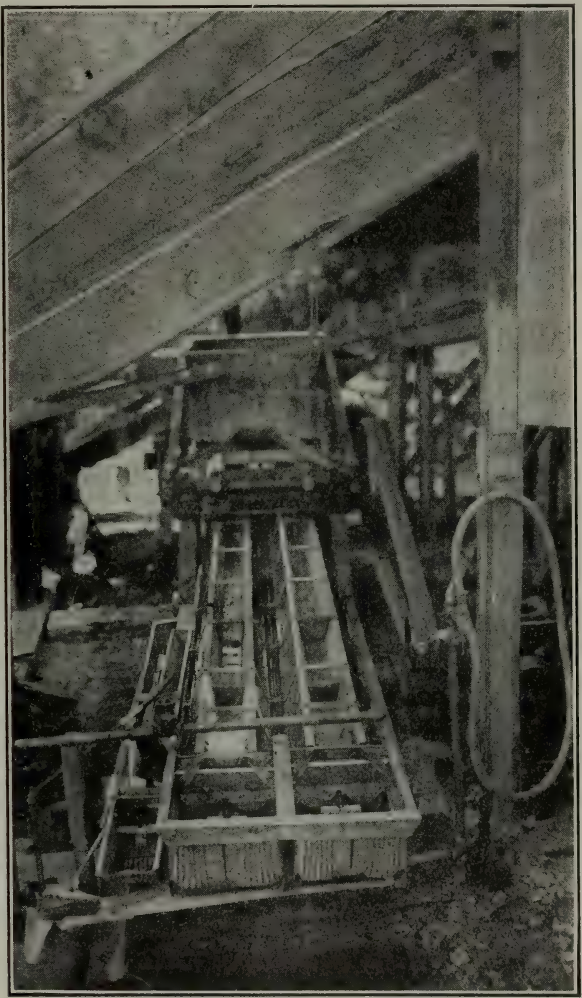
"Of particular interest is the Huelsdonk concentrator, a machine recently developed for gravels of this type to improve the recovery of fine gold and sulphides. The old conventional type of sluice-box is used to catch the coarse gold, as in the past, and the concentrator is placed below it, the discharge from the sluice being the feed for the concentrator. The photographs show two views of the machine. One is a shop photograph with the hopper in the foreground. The other shows the machine installed at the mine. In the background may be seen the sluice-box discharging into the hopper, which, by means of a rod and eccentric, is kept in violent agitation. The gravel is thoroughly washed, and the coarse material is rejected through the spout to the left. The fine material drops through a double screen in the bottom of the hopper to the vibrating tables seen in the foreground. These are very similar to Wilfley tables, but are made entirely of galvanized corrugated steel. The tables concentrate the fine gold and the black sand or sulphides and make an excellent recovery of them. The rated capacity of the machine is 75 tons per day. A 3-h.p. engine is required to run it. At the Vallecito Western Mine, Vallecito, California, a larger machine is handling 12 tons per hour; and the operators are very much pleased with the separation made of both the gold and the sulphides. The ideas embraced in the machine are certainly sound and result in a great improve-

[1] Logan, C. A., Platinum and allied metals in California: California State Mining Bureau, Bulletin 85, 1918.

[2] Averill, Chas. V., Mines and Mineral Resources of Plumas County, State Mineralogist Report XXIV, chapter 4. Mining in California, October, 1928.

ment over the crude methods commonly used to wash gravel; and the concentrator merits the consideration of anyone who is washing placer gravels."

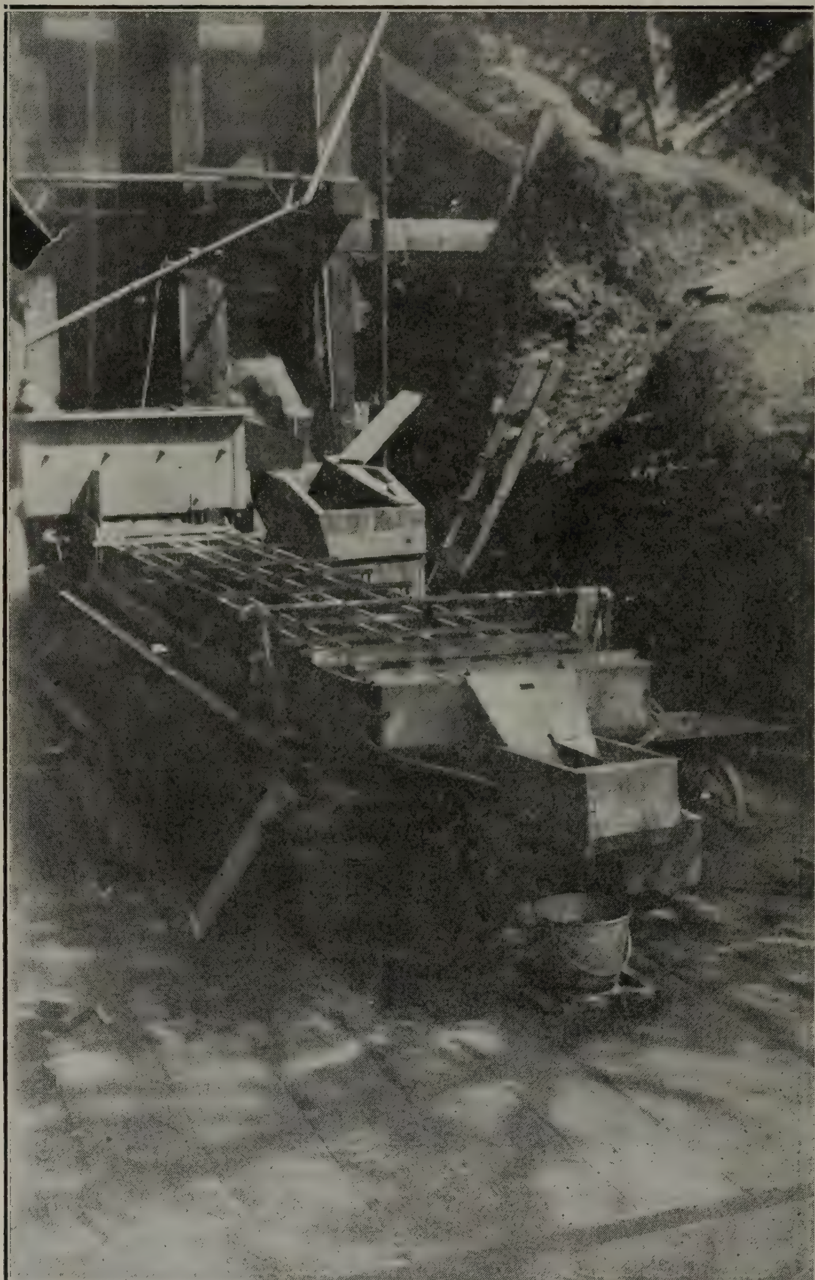
As now furnished the Huelsdonk Concentrator combines in an effective way the benefits of submerged grinding and jigging, followed by a shaking table which operates upon an entirely new principle. It is particularly designed for the treatment of auriferous gravels, but it



No. 49. Huelsdonk Concentrator at Glazier Mine, Plumas County.

can be adapted successfully to the beneficiation of hard rock ores under favorable conditions.

Operating conditions. The feed to the Huelsdonk Concentrator should contain enough coarse boulders to accomplish the grinding that is desirable in the disintegrator. Run-of mine material, no matter how coarse, is fed into the disintegrator at the top of the Huelsdonk machine.



No. 49. Three-unit Huelsdonk Concentrator in operation. End view. At Genii Mine, Butte County.

This disintegrator is an open rectangular steel screened hopper tank, having a flat screen of about $\frac{1}{4}''$ mesh wire attached well above the tank bottom. This whole tank is given a rocking motion by eccentrics on the line shaft, causing the water which is held in the tank bottom below the screen, to lift and surge violently. Therefore the screen never clogs or chokes, and no special watchfulness or care is required at any time. The disintegrator thoroughly scrubs and abrades every rock, cemented gravel, clay, or gumbo—rolling the mass over and over, with four hundred motions per minute. All oversize material, after being thus disintegrated, is rejected, and sent on its way to the rock pile through the discharge chute. Any nuggets too large to pass through the screen mesh are retained indefinitely under the gravel mass on the screen, whence they are recovered by hand at clean-up time.

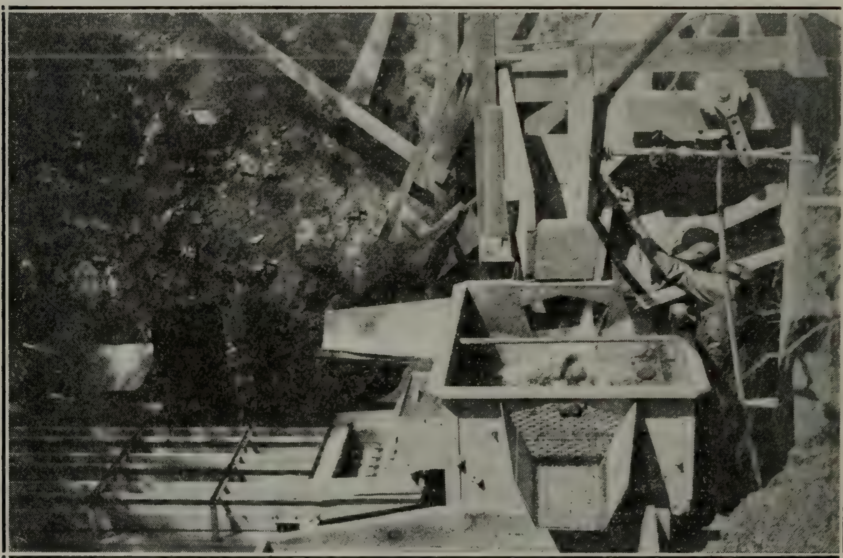
The undersize material, that which passes through the screen, leaves the disintegrator through adjustable gates into the feed magazine. Thence it flows to the distributor troughs, or cells, which extend lengthwise directly over the tables themselves.

In the older methods of concentration, fine flakes of precious metal float off and are lost in the tailings. This is because the flakes, or 'leaf' metal particles, have a broad area in proportion to their weight, and are consequently carried along with a current of water, in which a rounded particle would sink. It is for this reason that the regulation of water or grade for wash separation can not be depended upon for recovery of all the values. In the Huelsdonk Concentrator the tailings instead of being washed down stream with a current of water as on all previous tables are crowded up an incline across the riffles to the waste spout. The concentrates, free of slime, are then carried down a decline; the sulphides, black, and gray sands discharging from separate ports at the sides, and the precious metals going into a locked container at the extreme end of the machine.

Steel is used throughout in the building of the Huelsdonk Concentrator. The disintegrator and its screens are of heavy mill sheet steel, with steel liners which are easily replaceable. The quarter-mesh screen is protected beneath a heavy, coarser, screen with steel bar reinforcements. The distributor troughs and concentrator tables are made of heavily galvanized sheet steel, the riffles being formed out of the same material. The entire machine rests on a fabricated steel frame; therefore it is proof against wear and weather. In fact, the length of life of the Huelsdonk Concentrator can not now be stated, for none has yet worn out.

The Huelsdonk Concentrator will more than return its cost by saving that portion of precious metal which is lost in the older methods of separation. It is of the greatest efficiency in the recovery of 'rusty' and 'black' gold, from which the oxide coatings are removed by the violent scouring in the disintegrator. Also the clay, which would rob any sluice box of fine 'float' or 'greasy' gold, is completely disintegrated, and its values released so as to be caught on the tables below. Quicksilver may be used for amalgamation, but it is seldom necessary in the Huelsdonk Concentrator. If any old amalgam is present in the material being fed to the machine, it will be recovered along with the gold and platinum metals. On placer gravel, the Huelsdonk Concentrator will yield economically, in steady commercial operation, the highest percentage of recovery yet attained by any placer machine.

Upon first setting the Huelsdonk Concentrator in position it is carefully leveled and bolted firmly to its concrete or rock foundation. Then the material to be concentrated is fed into the disintegrator, and the action started. A competent mechanic from the Company's shops watches closely for the first few days, adjusting the feed, the openings of the discharge spouts and the distributor ports, and the slope of the riffles. During this time the man chosen for machine tender will have learned its simple construction, and can be left, with confidence that there will be no trouble in maintaining its satisfactory operation. The concentrator needs only ordinary oiling and cleaning maintenance after being once adapted to a particular run of material. The adjustments seldom ever require any change, barring accidents, and then if necessary can be quickly and easily effected.



No. 49. Three-unit Huelsdonk Concentrator in operation. Side view. At Genii Mine, Butte County.

A single unit Huelsdonk Concentrator of standard size has a disintegrator 2 feet wide by 3 feet long, by 2 feet 8 inches deep, and a distributor trough and table which together are 14 inches wide, 21 feet long and $2\frac{1}{2}$ feet high. The overall dimensions, then, of a complete single unit concentrator are approximately: 5 feet high, 26 feet long, and 2 feet wide.

Installations are built in multiple units under a single disintegrator, up to five tables in one assembly, 5 feet 10 inches wide, 21 feet long, and $2\frac{1}{2}$ feet high.

Recently (1931), there has been put in operation a 20 unit Huelsdonk Concentrator consisting of four assemblies of five units each, two assemblies extending in opposite directions on each side of a single large disintegrator. The overall dimensions of this 20 unit machine are: $6\frac{1}{2}$ feet high, 55 feet $10\frac{1}{2}$ inches long, and 15 feet wide.

In the multiple assemblies, each unit will handle just as much material as if it were used separately. In other words, the 20 unit

machine will cleanly concentrate about 80 cubic yards of placer gravel each hour of its operation.

A single unit Huelsdonk Concentrator will completely wash and concentrate the values out of about four cubic yards of placer gravel per hour. If fine quartz mill pulp is required to be concentrated, the feed would have to be slower, and the capacity on this class of material would be about one ton per hour.

While running the disintegrator screens never choke or clog up as the surging water from underneath prevents that completely; also starting or stopping regulation does not require especial attention for the concentrators as they do not lose their values by interrupted motion or continued water flow.

Either clean or muddy water may be used for mixing with the feed to the disintegrator, but a half inch pipe of clean water is desirable for final cleaning of the values at the foot of the tables. The total amount of water required for a single unit Huelsdonk Concentrator is 25 gallons per minute or $2\frac{1}{4}$ miners inches. About 125 gallons per minute are required for a five unit machine; and for a 20 unit, under one disintegrator, 500 gallons per minute is sufficient.

Power may be applied to the Huelsdonk Concentrator either by direct gear reduction to the line shaft, or by a belt and pulley drive. Only one horsepower is required to operate a single unit machine, and 5 horsepower for a 5 unit. The 20 unit concentrator, being so efficiently arranged with one side balancing the other, needs but 15 horsepower.

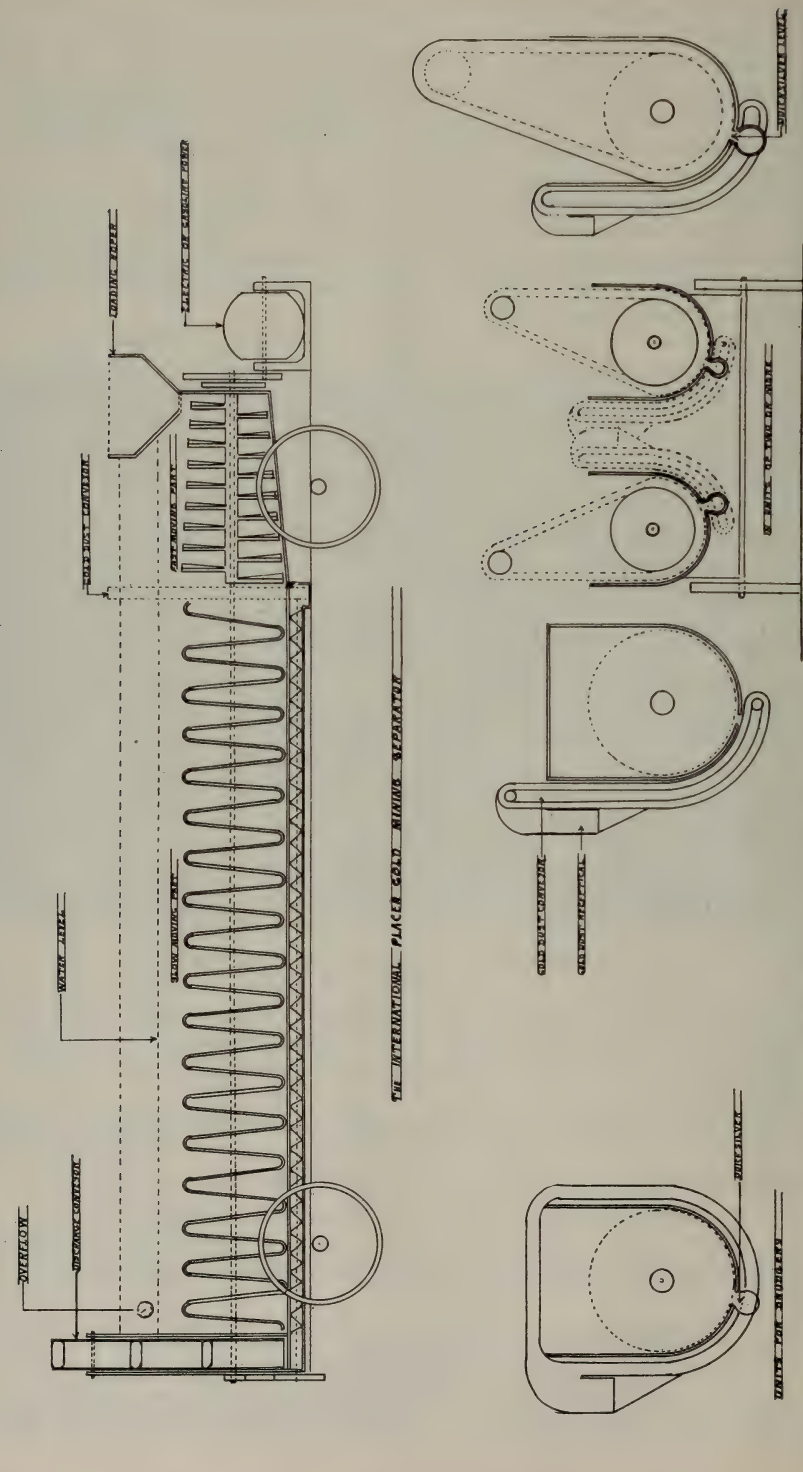
No. 50. International Placer Gold Mining Separator. The principle of this machine is shown by the accompanying drawing, but the machine as built varies from it in details. It consists of a long round-bottom trough with a slot in the bottom in which is an enclosed screw conveyor. This small conveyor pipe is filled with quicksilver to the level of the bottom of the main trough. In the main trough there is a spiral conveyor made up of a series of arms or paddles on a shaft which works the gravel from the head end to the tail end. Here it is picked up by a small perforated-bucket elevator which carries off the tailings, the water being returned. The trough is filled with water kept at a constant level, only enough being added to replace that carried off by the wet tailings. As the gravel is worked along, the gold, platinum and any other minerals having a heavier specific gravity than mercury will pass through the slot in the bottom and either amalgamate with or sink into the quicksilver and be carried by the small conveyor in the opposite direction, to a trap.

The original machine was substantially constructed of heavy metal and operated by a gas engine. In a preliminary test at the plant about 3 yards of gravel was passed through it in 8 minutes.

No. 51. I-O Separator. An electro-static separator, the separation of various minerals being made by ionization of the particles, hence the name. Developed in Colorado. No further details are known to the writer.

No. 52. Johnson Dry Concentrator. The following notes and drawing have been supplied by the manufacturers:

The machine is built on entirely new ideas, and has several new features, which, together with the controls and adjustments make it a



No. 50. Sketch showing construction of International Placer Gold Mining Separator.

simple, efficient, and practical machine. It is built entirely of steel, on a strong, rigid, tee and angle iron frame, and is perfectly capable of standing the rough usage a machine of this class is subjected to.

The table is 2′ wide and 12′ long. The machine is 3′ 6″ wide, and about 16′ long, and the hopper is 18″ high. The machine weighs about 3000 pounds. It can be taken down for shipment, the heaviest part weighing 200 pounds.

The feed is a pocket roll feed of a new design. The pocket extends the full width of the table, and places the gravel and pulp in an even layer the full width of the table. The feed roll is driven by a ratchet disk and lever (4) and rachet (3). Controlling lever (5) carries a guard which disengages ratchet (3) by placing lever (5) in the central position. There is no motion imparted to the feed roll by moving lever (5). The speed of the feed roll can be increased from nothing to the full capacity of the machine while the machine is in action. Thus the operator, by simply moving lever (5), has complete control of the amount of ore fed from the table.

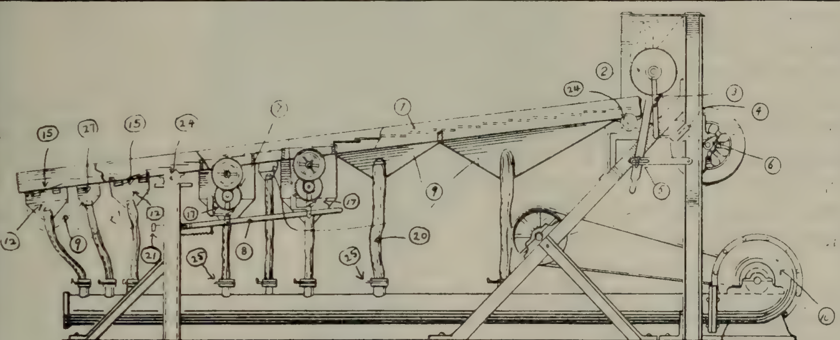


FIG. A
Elevation

No. 52. Johnson Dry Concentrator.

The method of applying the air is different from that in general practice. The air is not forced up through the ore, but passed between the riffles in a line that the ore is traveling in, which does not blow the fine values on top to be settled again or lost. The surface of the table is composed of a period of steel riffles one-sixteenth of an inch thick and over-lapping each other about one and one-half inches, and held apart by washers one-eighth of an inch thick. The air is admitted through pipe (10), slide valve (25), flexible hose (20), into air pan (9). There are a number of separate air pans to enable the operator to control the amount of air under different parts of the table, which is very essential. The air passes between the riffles in line with the traveling ore, helping its action down the table and causing an agitation the full width of the table at every riffle. The agitation causes the heavy particles to settle to the bottom as they pass down the table.

The main feature, and one that has made the machine a success, is a method of collecting the concentrates. It is composed of a corrugated roll (11), 5½ inches in diameter. There are two of these rolls.

They extend across the table as shown in collector feed detail. The rolls are driven by a train of gears (7), and ratchet. The ratchets take their motion from a lever or rod (8), which is controlled by a set screw (21). By screwing set screw (21) in or out, the speed of the roll can be increased or decreased while the machine is in motion. By this control the operator can take just as little or as much concentrates as he desires. The advantage can be seen in being able to control the amount of concentrates taken, to suit the character of the ore handled. This is said to be a feature no other machine has.

The operation is this: the heavy particles, having been settled, pass down the table until they pass riffle (18), which is about $\frac{1}{8}$ inch above the collecting roll (this space can be adjusted to suit the ore handled). There is an opening under the roll of about $\frac{5}{16}$ of an inch (this also can be adjusted). Across the opening is riffle (19), with a bevelled retarding strip attached to it. There is a $\frac{1}{16}$ of an inch opening between the roll and the retarding strip. The object of the opening between the roll and the retarding strip is to allow the air to pass through into the ore. The air passes into the air pan (17), which is also the concentrate hopper, and passes around the collecting roll both ways. The heavier particles drop down through the opening and the air onto collecting rolls, and are carried into the hopper (17), to be discharged into a concentrate bin (not shown). The lighter particles, and also the larger pieces, are worked up the inclined surface of the retarding strip (19), and go into the tailings. Nearly all the values are caught in the first roll. The second roll is more for safety. The concentrates from it are run over again as they are very low grade. The collecting device is the main feature of the machine.

The last, but not the least feature, is the nugget collector. It will be readily seen that no large pieces can get on the collecting rolls through the small opening. They are worked over the retarding strip (19), and pass down the table to the nugget collector (15), of which there are two. They are composed of a set of inclined riffles (15), forming a pocket. The air passes into the pocket between the riffles (15), keeping the ore agitated. The heavy nuggets settle in the pocket, which is hinged to the table by loosening a thumb nut. The nugget collector can be dropped and its contents taken out while the machine is in operation. This saves the large nuggets which otherwise would go into the tailings.

There is a device at the lower end of the table for raising or lowering the table to any desired pitch, for different classes of ore.

The table is actuated back and forth by pitman (6), and by moving the pin in or out in the slot, any desired stroke may be given the table.

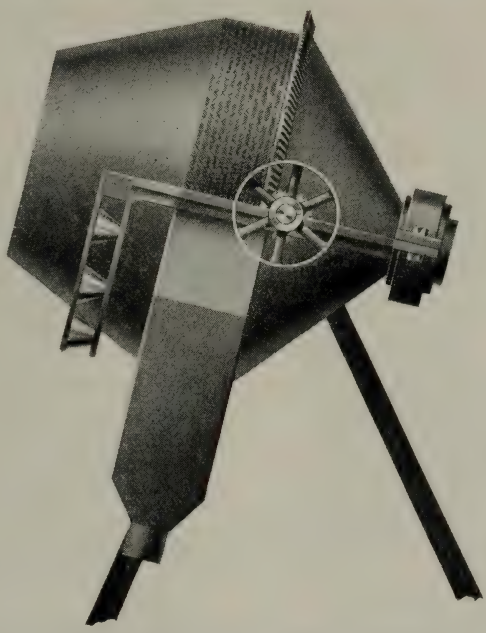
This machine will handle any fine sand or it will handle loose gravels that have been passed through $1\frac{1}{4}''$ mesh screen without any further classification. It will also handle concentrating ores that have been crushed through ordinary mill screens. It makes about the same saving of values in this class of pulp as a water table will make. Its capacity is from two yards to six yards per hour.

Taking the construction of the machine, and the new features, together with the adjustability and control of the different devices while the machine is in operation, this machine is suitable for the handling of

a wide range of material. The machine is simple and can be handled by any operator.

No. 52½. Jumbo One-man Placer Machine is a product of the present depression, having been designed for use by the man of small means, enabling him to extract the values at an extremely low cost—about 50 cents per day for gasoline and oil to run the engine.

The machine consists of a revolving conical shaped drum with a heavy grid screen in the center, six inches wide, over which is placed a finer mesh screen. The fineness of the outer screen is determined by the fineness of the gold or other metal content which it is desired to extract. The action of the sand and gravel revolving in the drum has a tendency to scour the gold, preparing it for quick amalgamation.



No. 52½. Jumbo One-man Placer Machine.

The fines pass into a hopper and are then passed over an amalgamator or small concentrator, or both, as may be required. One man can put through the machine from ten to fifteen yards of gravel per day, depending upon his ability to shovel and the condition of the deposit. Gravel running as low as 50 cents per yard will pay him good wages.

One distinct advantage is the comparatively small amount of water required when treating damp or wet material. It can also be used dry, providing the material is perfectly dry.

Numerous mine dumps contain 'fines' which contain good values, and which can be treated with this machine at a very nominal cost.

The machine is entirely portable, mounted on wheels, and can be dismantled so that the heaviest part will weigh less than two hundred pounds.

No extravagant claims are made for this machine, and it requires only a good day's work on the part of the operator and the values in

the material treated, for the operator to make good money. Price f.o.b. San Francisco, $300.

No. 53. Kellogg Black Sand Machine. This machine has been described by both Logan and Haley. Logan, in describing the method of recovering platinum from black sand obtained in dredge operations in the Oroville district, says:

"Some of the clean-up men at Oroville have made use of the Kellogg black-sand machine to recover the platinum from the long-tom concentrate. In principle, this device is an inverted funnel with pockets around the circumference. The sand and water are poured down the sides and the concentration is brought about by the boiling action when the mixture flows into the pockets. This gives a very rich concentrate about 50% metal. The machine appears to be a good saving device. A recent clean-up made with it gave 4⅜ ounces platinum. The residual black sand from the clean-up was treated chemically and was found to contain 90 grains of platinum. This would indicate a recovery of slightly over 95% with the appliance."

The manufacturer of the Kellogg machine is not known.

No. 54. Kimball Concentrator. A machine wherein centrifugal and hydraulic forces are operated under perfect control and whereby practically 100% of all free metal of greater specific gravity is recovered from the sand of placer or quartz mill operations, black sand particularly, regardless of the fineness thereof.

A standard size machine has a capacity of from 5 to 10 tons an hour, depending on the fineness of material and nature of metal recovered, and requires from 3 to 5 horsepower to operate, and water from 20 to 25 gallons per minute per ton of sand per hour.

Machines may be installed singly or in batteries if larger output is required.

Action of machine is nearly automatic, no skilled labor is required and one operator can handle five machines as well as one.

In addition to the larger metallic particles, the Kimball Concentrator recovers the fine and microscopic values which in other operations pass over and are lost from sluice boxes, canvas plants, concentrating tables, jig concentrators, vanners, etc. Reduces volume 50 to 1, or 100 to 1, if desired.

Installation cost is about one-tenth that of flotations, cyanide or concentrating table plant handling the same amount of material.

One machine will do the work of six concentrating tables and accompanying vanners, and requires only a floor space 6′ by 8′, head room of 7 feet, and an inexpensive foundation.

The following is a report from the D. M. Wood Laboratories indicating the fineness of gold that has been recovered by this machine:

Certified Chemist
American Board of Shipping

Affiliated with
Porro Biological Laboratories

D. M. WOOD LABORATORIES
CERTIFIED CHEMICAL ANALYSES
517–518 Provident Building

Tacoma, Washington, December 18, 1929.

MR. S. C. KIMBALL,
Tacoma, Washington.

DEAR SIR: We have examined the sample of concentrate which was submitted as obtained by the user of your concentrating machine from sand at the Butler-Qumalt Mine.

This material was examined microscopically, using various magnifications, from 250 to 1200 diameters. We found numerous small particles of gold and plati-

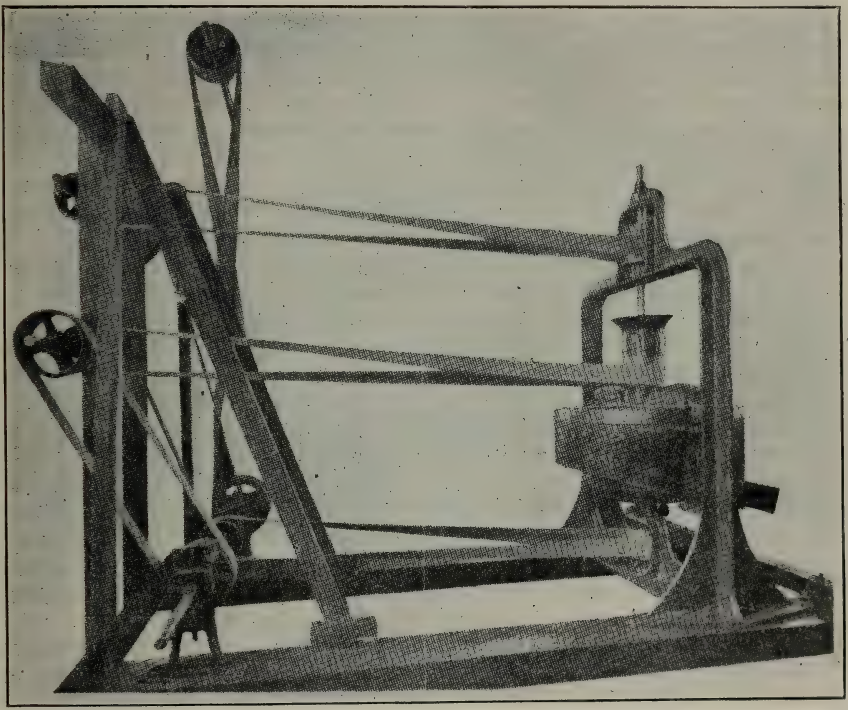
num in this concentrate, all too small to be seen by the naked eye, in fact the majority were too small to be seen under 250 diameters.

The sample submitted was too small to attempt any assay of the material so no idea could be obtained of the actual value of the sample.

D. M. Wood Laboratories,
(Signed) D. M. Wood.

Mr. Kimball now resides in California and the machine is manufactured here.

No. 55. Leach Dry Washer. A dry-placer gold recovery machine developed by Mr. Leach from whom additional information will have to be obtained.



No. 58. Logan Centrifugal Gold Extracting Machine.

No. 56. Leupold Dry Recovery Process. This is also a dry extraction method for placer gold and platinum. Developed in Canada. The inventor is looking for a place to operate in California. No description of this process is available to the writer.

No. 57. Lincoln Flour Gold Concentrator. The company states that they have perfected and patented a new concentrator for handling flour gold, which has been tested and proved to do all that is claimed. The machine is to be manufactured in sizes to meet the needs of the small single operator as well as those of the largest dredges. Further information may be obtained from the manufacturers.

No. 58. Logan Centrifugal Gold Extracting Machine. This machine, patented in 1926, is designed to save fine gold without the aid

of quicksilver. It is claimed that it will make practically a 100% recovery of gold even when so fine that it will float on water. Testimonials of men who have seen the machine under actual working conditions are submitted. Most of the tests were made on gold-bearing earth in Georgia and Virginia, the machine being manufactured in the East. It is said to have a capacity of approximately 50 tons per day and is intended for placer mining, stream shovel operating, dredging, free-milling ore, old dumps that have been passed over amalgam plates, or for any conditions in which the gold can be liberated from foreign substances.

No. 59. Lorentsen Centrifugal Fine Gold Recovery Machine. This apparatus is described in Engineering and Mining Journal[1] as a machine that utilizes centrifugal force, successfully it is said, in amalgamating free gold ores, placer sands, concentrates from sluice boxes, and so-called black or magnetic sands. The machine which is patented is called the Lorentsen centrifugal fine-gold recovery machine. According to the company it is made in various sizes, is ruggedly built, and can be easily handled. The size with which the company has had the most field experience handles 1 cu. yd. of concentrate (averaging 4300 lb.) per hour, and requires a little less than 2-h.p. to operate, the friction being slight owing to the use of ball bearings.

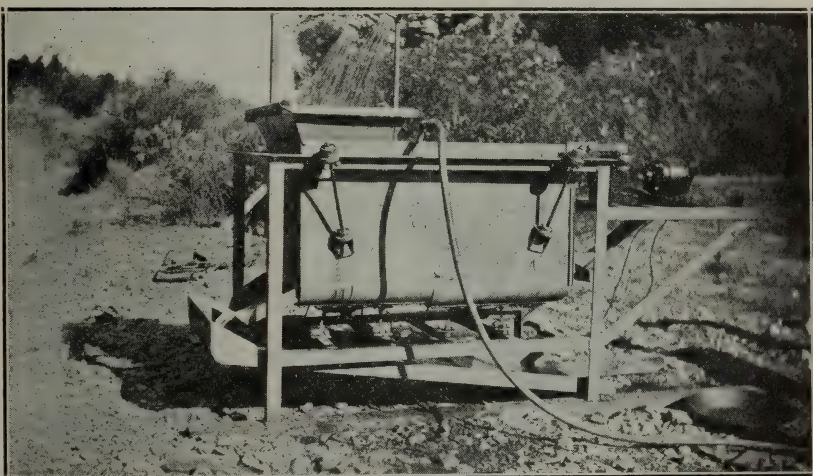
Essentially, the device consists of a bowl mounted in a casing, and rotatable at any desired speed. To operate it, mercury is placed in the bottom of the bowl, which is then rotated until the mercury spreads out over the inside through the action of centrifugal force. The sands or other materials to be treated are then introduced with water into the feed pipe of a centrifugal pump, which is specially arranged so as to deliver the pulp from the bottom of the bowl in such a manner that its angular velocity exceeds that of the bowl. This facilitates its distribution evenly on the surface of the quicksilver. Attached to the feed pipe are four arms that revolve with the pump and at equal speed. To these, in turn, are attached flexible devices which, as the machine revolves, throw out blades which travel parallel to the mercury wall and close to it, thus serving to agitate the materials as they travel upward toward the edge of the bowl.

Under the action of the centrifugal force, the component parts of the sands treated tend to separate, the heavier particles moving to the outside, where they penetrate the mercury and are held against the wall of the bowl. Clean gold is quickly amalgamated and rusty or greasy gold (and platinum) is retained against the wall until the rotation ceases. The sand or other material, of lesser specific gravity than that of mercury, passes over the surface and out over the edge of the bowl. When the machine is brought to rest, the quicksilver is scooped out, strained and retorted in the customary manner. A machine such as this, capable of handling 1 cu. yd. of concentrate or 2 to 3 tons of milling ore per hour, will require about 50 gal. of water per minute, which will also suffice for removing the tailing. If water is scarce, some method for circulating it can readily be devised. According to the company, the machine has been tried out under exacting conditions on beach-sand concentrate of Graham Island in the Queen Charlotte Group, British Columbia. Difficulties were

[1] Amalgamating Gold Ores and Sands with Aid of Centrifugal Force, Engineering and Mining Journal, September 14, 1931.

great, the camp being two days away from any source of supply. The machine used (1 cu. yd. of sand per hour) has handled approximately 1000 cu. yd. of concentrate and has made continuous runs, it is said, under critical examination. In a month's trial it made a recovery of 93%, and since then has done substantially better, owing to improvements made. R. G. Mellin is quoted as reporting that out of twelve samples of tailings taken and assayed, the returns from one gave a trace of gold and the remaining eleven showed none. On treating sand around Martell Creek an average recovery of $2.11 per cu. yd. in gold was made out of a total of $2.25 per yard.

Loss of quicksilver was practically nil, native quicksilver being said to be recovered in the course of operation. In experiments on a smaller scale, the company says it has handled almost every kind of crushed ore containing free gold, including talcy ores. The machine has been found to do exceptionally good work in amalgamating gold from 16-mesh and under.



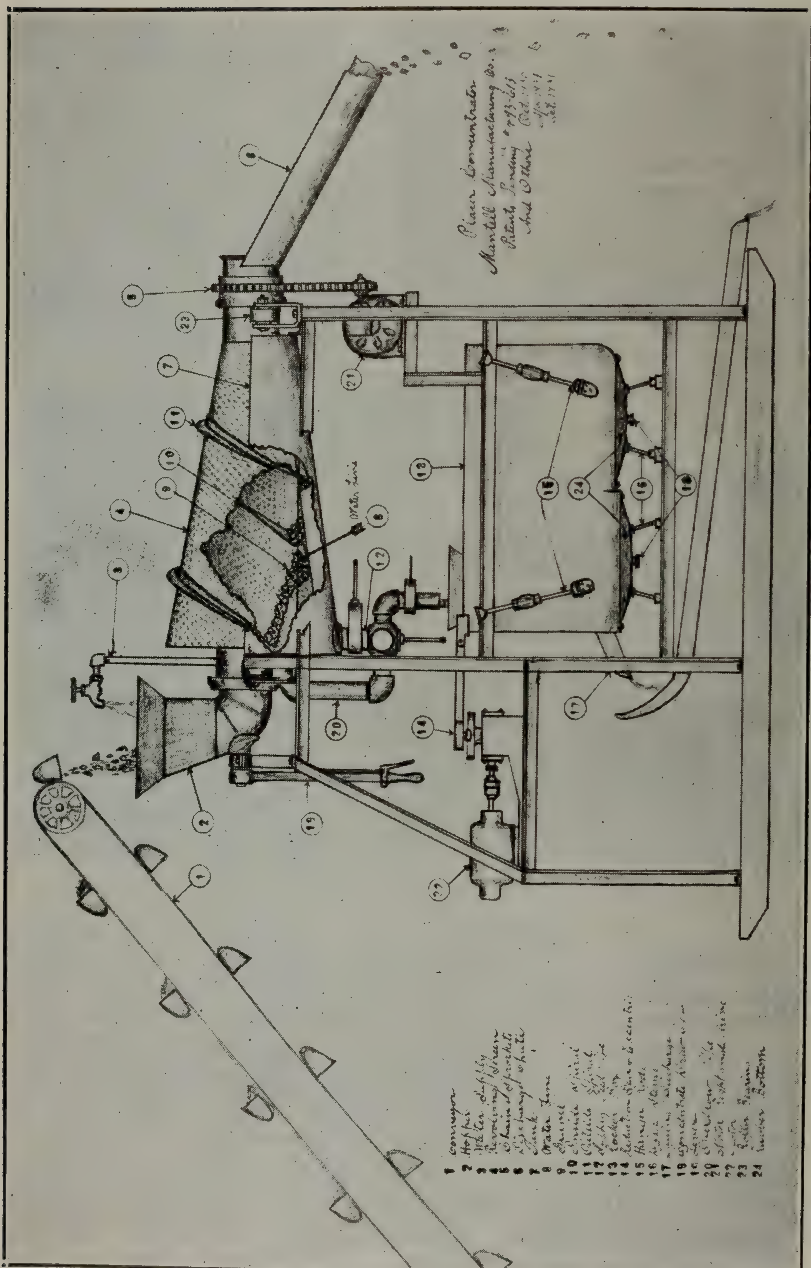
No. 64. Mantell Concentrator being tested on Wildcat Creek.

No. 60. Luckenbach Process. This is understood to be a special mercury amalgamation process, applicable to hydraulic or dredging operations for the recovery of gold and platinum in black sands. Further information will have to be obtained from the inventor.

No. 61. Macartney Dry Concentrator, saves the values in placers, giving a 90% recovery and handles 15 tons per hour according to the announcement of the inventor from whom further details may be obtained upon request. This machine is the same as No. 3, which see.

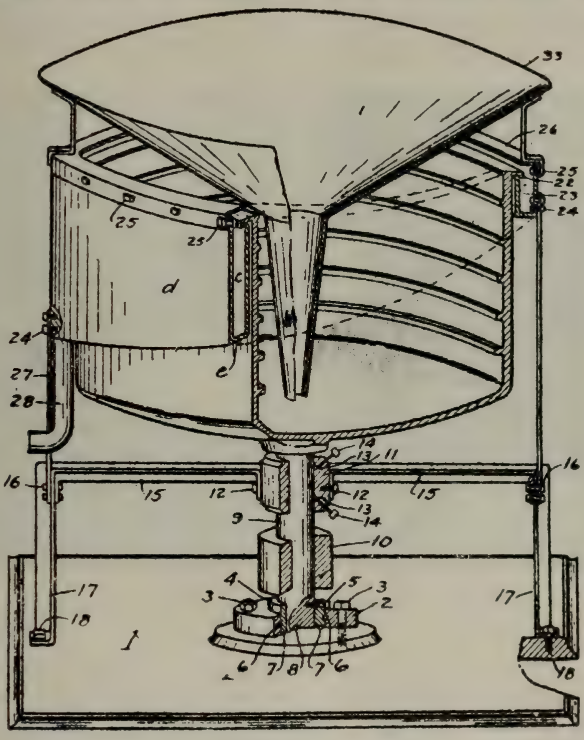
No. 62. Madden Mining Method. A new method of mining for fine gold in river beds. Details will have to be obtained from Mr. Madden.

No. 63. Mammoth Amalgamator. This machine operates similarly to the McBride Process (see *post*) in that it uses sodium amalgam, though produced by a different method. Further details will have to be obtained from the inventor.



No. 64. Mantell Placer Concentrator, showing screening section attached.

No. 64. Mantell Placer Concentrator. The principal of the Mantell machine closely follows that of the miner's pan. The construction and operation are clearly shown in the cut. The photo shows one without the feeding and screening portion, used in a test held on Wildcat Creek 10 miles east of Oakdale. The double panning section is suspended on hangers and motion imparted by an eccentric. The bottoms of the pans are made of rubber fabric to each of which is attached four metal disks with stems which rest on cross members. When in operation this gives an undulating motion to the bottom, alternately opening and closing cracks in the heavy black sand and permitting any fine gold or platinum to work to the concentrate draw-off. But little power is required and a half-inch pipe will furnish



No. 66. Matrix Amalgamator.

sufficient water for operation. The manufacturer's recommend a separate engine and generator unit with individual motors on the machine and to operate a water pump as the most flexible arrangement, rather than a gas engine direct connected to the machine.

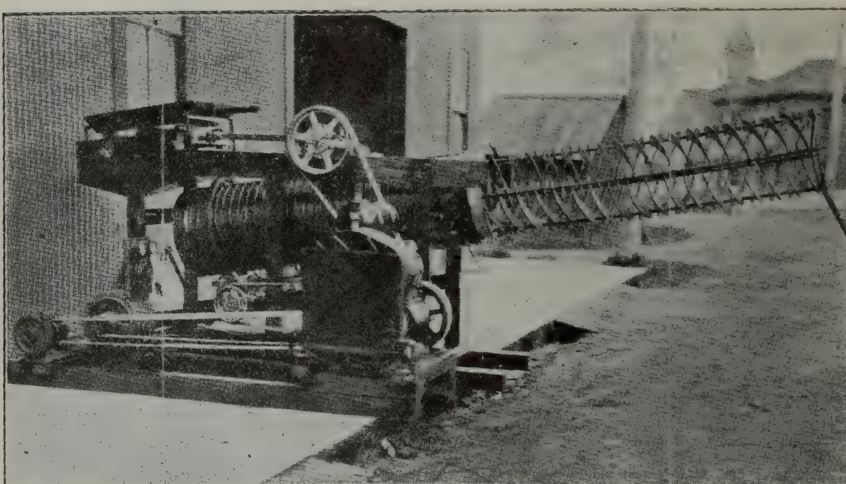
No. 65. Marsh Electric-Magnetic Separator. An electric-magnetic separator which works under water and with which it is claimed all fine gold can be completely separated from black sand.

No. 66. Matrix Amalgamator. This device, of the bowl type, according to a circular issued by the inventors, Geo. E. Banks and Harold N. Banks will recover free gold and platinum from placers and shattered ores, whether rusty, greasy, floating or other kind.

In placer operations the coarse material, larger than a pea, is screened away allowing only the fine material that carries the values to enter the bowl, which greatly increases the earning power.

In milling work the amalgamators assume the places of tables and plates. They are built in two sizes with capacity of one and two tons of fine material per hour. Power required one and two horsepower. Mercury five and ten pounds for each charge. They are claimed to have been successfully demonstrated and operated on placers in Utah, Nevada and Washington, on the black sands of British Columbia and on the Oregon coast.

No. 67. Maynard's Flour Gold Concentrating Equipment. This party has a special system and equipment for recovering flour gold, which he claims is highly efficient. No details concerning this process are known to the writer but they may be obtained from the inventor.



No. 68. McBride Cylinder Amalgamator, showing fin assembly ready to be placed in cylinder.

No. 68. McBride Cylinder Amalgamator and Process. The apparatus consists of a cylinder made of wood, mounted within two circular rails, which in turn roll upon trunnion bearings. Inside lining and cylinder is the plate.

Resting upon the plate is a helical 'fin flight' assembly, made of semi-vulcanized rubber, staggered, being interrupted at each quadrant. This spiral fin assembly suggests that which is found in an Aikens classifier. The plate, the spiral fin assembly and cylinder rotate as a unit. The fins extend upwards from the plate a few inches, varying with the size of the cylinder. There remains, therefore, a considerable open cylindrical space within the spiral fin assembly. Suspended within at the lowest point, just clearing the upper edges of the fins, is a carbon electrode (the anode). It is stationary and does not revolve with the cylinder plate and spiral fin assembly which revolves as a whole upon the trunnion supports. When mounted the cylinder is set so that the intake end is lower than the discharge end. Also the

fins gradually diminish in heighth from the intake end as one progresses towards the discharge end.

The process is the application of several well-known and long-established principles and actions, so arranged and coordinated as to make use of each step in proper and useful sequence and virtually getting into step with the operation of natural law and avoiding violent opposition thereto.

The outstanding feature is providing an amalgamating plate, the mercury on which is continually being supplied with sodium, so that on it at all times is a very active sodium amalgam.

It is accomplished in this manner: the gangue of say 20% solids is introduced into the lower end of the cylinder which is closed except for a circular aperture in the center of the cover closing the lower end of the cylinder. The gangue enters by means of a simple launder. The water has salt added to it before it enters the cylinder. Sea water has been used very successfully. Now, when the pulp has entered the cylinder, the spiral fin assembly very effectively but gently rolls it progressively forward up the grade. A current of d. c. electricity is introduced, and passes from the carbon anode, through the pulp, to the plate underneath. The plate serves as the cathode.

The current decomposes the sodium chloride, and sodium and chlorine results. The sodium presumably becomes sodium hydrate in most instances and as such or sodium, passes promptly to the plate. But when it strikes the plate, the hydrogen is released, and sodium metallic is formed and it having so slight a specific gravity virtually 'pops out' again and in coming in contact with the water forms sodium hydroxide (caustic soda).

Where there is even considerable oil or grease present the caustic soda is quite sufficient to promptly saponify it, and in cases of certain oxides and other substances coating gold the inventor claims to have found the action prompt and effective in cleansing the metal for ready amalgamation. The chlorine escapes mostly as gas, for its odor is marked when the machine is in operation. Yet, considering the well-known tendency of chlorine for recombination it possibly serves usefully in other ways. In thinking of the chlorine, it should be borne in mind that the operating temperature of the process is a low one being that of the water supply.

"The effect of a current of electricity upon tiny particles of gold, silver or platinum is not clearly understood by many. Nevertheless, we have learned that it does serve very positively, effectively and usefully when applied with understanding."

The physical action supplied by the spiral fin assembly can be only compared with skillful panning. The cylinder, revolving slowly, provides a gentle rolling motion to the pulp, avoiding sliding, and yet classifying sufficiently that every particle is exposed to the amalgamating plate long before it reaches the discharge end. Therefore, the presence of black sand or magnetic ore offers no difficulty whatever, but on the contrary seems to assist in the useful distribution of the electrical current.

Under drastic test conditions it has been determined that 80% of the extraction is effected in the first 25% of the apparatus, or saying it differently, 80% of the metal extracted is recovered on the first quarter of the plate.

Operating upon fine sands, semi-concentrates or concentrates, competent engineers are stated to have accorded the process the extraction efficiency of 99%, while the inventor claims 95%. "It is understood that we claim this efficiency on free metallics."

The successfulness of its action is based principally on destroying surface tension. The very reason mercury flours so readily is due to the fact that because of its density and surface character, it provides for pronounced surface tension. The tiny speck of gold, even though of much greater specific gravity, does not enter the mercury when in contact with it because the surface tension of the mercury does not permit it. The phenomenon is like that of the needle floating on water. Besides the surface tension affects the particles of gold and silver and even more so, the platinum.

Two sizes of apparatus have been developed. One is portable to the extent that it can readily be taken apart so that it can be packed on burros.

It has a capacity of not less than 1½ tons of fines or concentrates per hour. The cylinder is 18 inches in diameter and is 6 feet long. Additional equipment consists of a small d. c. generator, circulating pump for water, and a 4- or 5-h.p. gasoline engine. The size deemed most practical for large-scale operation, is 3 feet in diameter and 12 feet long. This size is the unit for battery installations. Its capacity is 15 tons per hour.

The smaller cylinder complete will weigh about 600 pounds. The larger one will weigh under 3000 pounds.

The items of cost of operation are power and salt. Under test conditions 3 h.p. revolved the large cylinder and supplied the needed electrical current. Salt consumption will vary from 3 ounces to one pound per ton of solids, depending on dewatering efficiency applied to pulp after treatment. There are so few moving parts and they are so simple that wear is slow.

No. 69. McLeod Gold Saving Machine. Nothing is known regarding this machine except the name and address of the Seattle party who has it.

No. 70. McMillan Placer Apparatus. Mr. McMillan is designing a mobile placer mining and gold-recovery plant for installation at a deposit in Trinity County. The equipment will consist essentially of a power-shovel mounted on caterpillar trucks which delivers the gravel by means of a conveyor to a trailer carrying the screening, washing, gold-saving equipment and stacker for tailings. Some details of the final lay-out have not as yet been definitely decided.

No. 71. Miller Metals Separator, is another device for saving tailings values concerning which no details are at hand.

No. 72. Mitchell Patented Sluice Box and Riffle. A new type sluice box and riffle board invented by H. C. Mitchell. The device is said to contain two outstanding features which none of the more than 7000 patents designed to save 'flour' gold in placer mining combine.

First, the machine is so constructed that it can handle volume unlimited, according to claims made for it.

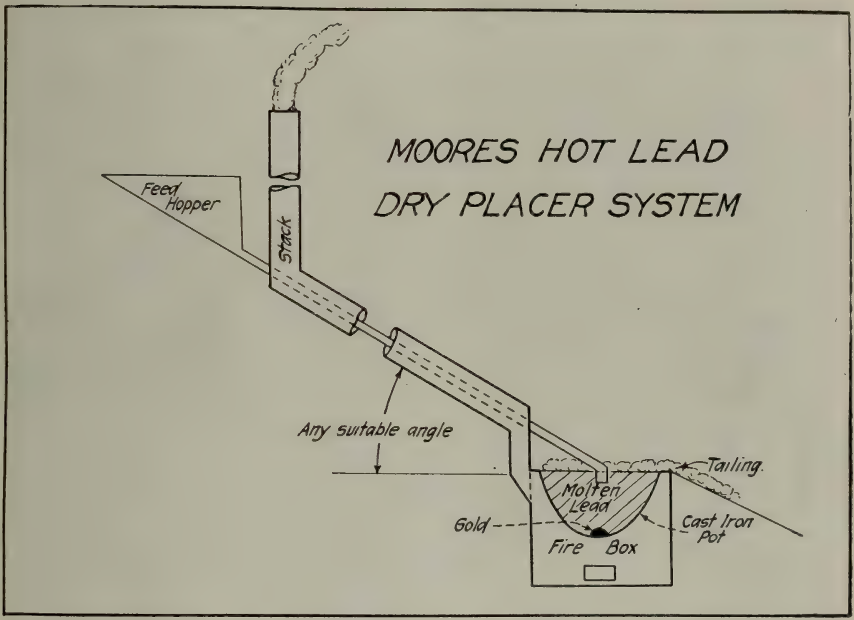
Second, the screens in the sluice box run from a $\frac{1}{32}$ of an inch to a fineness that water scarcely will pass through, and underneath the

last screen is the riffle-board of wood, two inches thick. The slope, form and size of the riffle is the feature that saves the flour gold.

The riffle is a quarter of an inch deep at the upper end of the board and one and a half inches deep at the lower end. Its width tapers from top to bottom. The riffle also is undercut and the water whirls the gold and black sand in this undercut and finally passes it out at the lower end through an opening, regulated by slides, into a shallow trough.

The trough or 'launder' is lined with burlap or carpet, the nap of which catches the gold.

The device is claimed to be 98% efficient or far greater than any other sluice now operating.



No. 73. Moore's Hot Lead Dry Placer System.

No. 73. Moore's Hot Lead Dry Placer System. This scheme for recovering gold or platinum in localities where water is not available originated from watching a small boy toss an iron bolt into a pot of molten lead and noting that the iron floated. The basic idea is, that if gold-bearing sand and gravel is submerged in molten lead, the gold being heavier than lead will sink and the other material will float and may be raked or scraped from the surface. It is proposed to feed the material into the molten lead through a pipe which is surrounded by the flue from the firebox so the gravel will become as hot as possible before it enters the lead bath, thus conserving fuel.

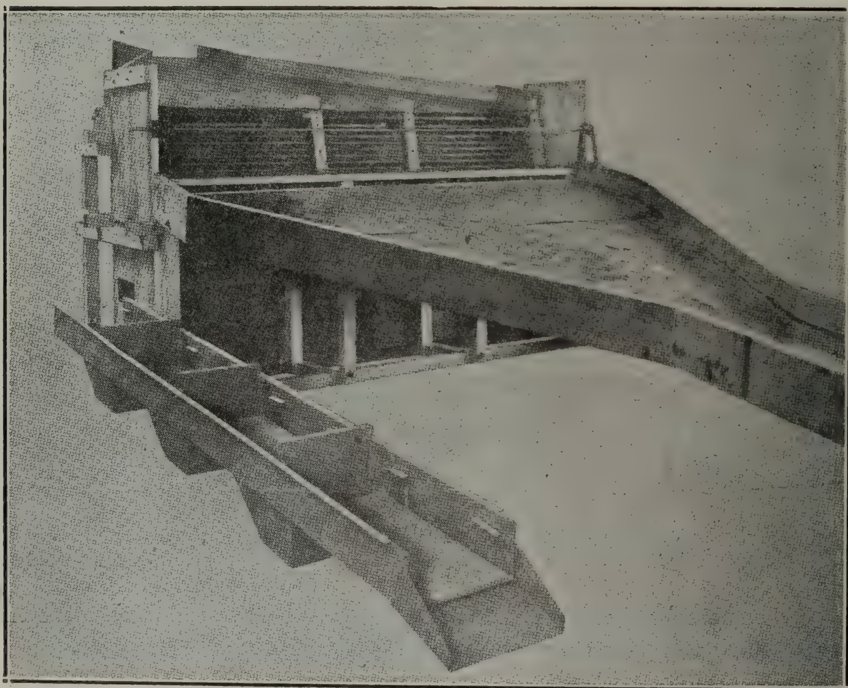
In an experiment Mr. Moore claims to have made a 100% recovery of filings from a gold coin mixed with sand and gravel and subjected to the treatment, stating that after cooling, the bottom of the lead mass was sawed off and all the gold reclaimed.

Any fuel may be used and if necessary a screw-conveyor or other means may be used to feed the material. The tailing may also be removed mechanically.

No particular form of construction is given but the sketch herewith will show the principles involved.

Assuming that the process itself is 100% perfect there are obvious reasons why it would only be applicable to very rich concentrations.

No. 74. Moore's Suction Undercurrent System. Consists of a main sluice with one or more openings in the bottom covered with a perforated plate over a V-shaped box. These undercurrents have a strong suction effect, a whirlpool forming in the sluice over each one.



No. 75. Adjustable grizzley suitable for using undercurrent product over Mat-O-Gold equipment.

It is claimed that any flake gold that may be floating on the water is tipped up on edge and sinks below the surface, when it reaches the vortex of the whirlpool. A series of any number of these suction undercurrents may be installed depending on the layout of the workings and amount of fall available. This system was used in Humboldt County at the Klamath River Mine by Mr. Moore.

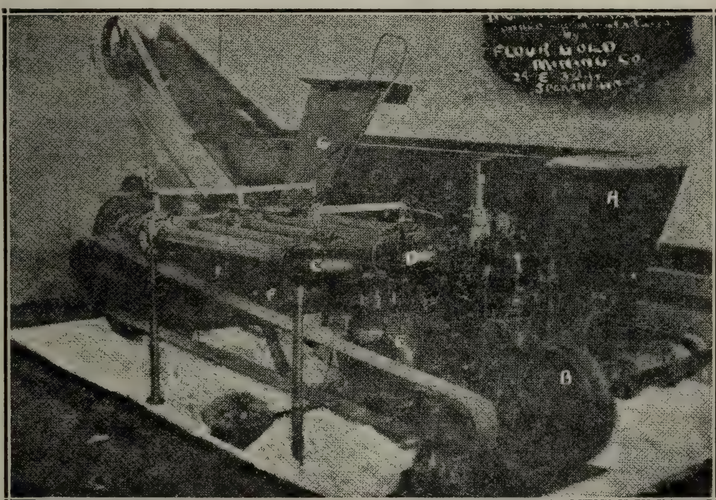
No. 75. Morgan's Patented Mat-O-Gold. The mat-o-gold is a rubber slab or mat of sponge-like, cellular construction, and is the basic idea around which various mining equipment is built by the Morgan Company. It has a multitude of resilient rubber cells that constantly vibrate while in use, and catch and hold the values, allowing the lighter particles to float away. It will not slime and has great wearing qualities.

It is further claimed that it forms a perfect riffle and positively will not pack, and is easy to clean without removing from position. All the defects and short comings of blankets, carpets, corduroy, canvas, cocoa mats, etc., are said to be overcome by this device.

This sponge rubber equipment has been used in the miner's pan, and rocker, in undercurrent boxes and sluices and as an endless belt on vanners, being adaptable to both placer mining and gold milling practice.

No. 76. Morrison Amalgamator. In the Morrison Amalgamator the secret of its success lies in the fact that the sand or ore is treated electrically and every particle of gold or platinum, no matter how minute, is brought into direct contact with the quicksilver.

The pay-dirt is sluiced into hopper 'A' through pump 'B' into U tubes 'C' and 'D.' It is then treated in a chlorine gas manufactured



No. 76. Morrison Amalgamator.

from salt water by electrodes inclosed in U tubes. Also sodium solution can be used instead of the salt and doing away with the chlorine. Electricity furnished from generator 'E.'

The baffle plates are fashioned to work underneath the quicksilver and the pay-dirt in making its escape is wholly submerged in the surrounding quicksilver in the mercury pot 'F.' The tailings then pass through baffle plates 'G,' which are electrified to prevent the escape of any mercury or amalgam. Amalgamated plates electrified can take the place of mercury pot 'F.' It requires a three horse-power engine to operate the amalgamator, including the manufacturing of its own electricity.

One of the problems which has baffled mining operators is that of the slimes and bubbles caused by the chemical action which takes place when fine gold is brought into contact with mercury. Especially is this true of the product of the mill. Crush the ore coarse and the fine gold is not released from the rock, but crush it too fine and the slimes and bubbles carry off even greater values than the coarser rock. The

5—94259

result has prompted miners to incline to the former method rather than to the latter, well aware though that they did not save the values to which they were entitled.

After the precious metals are cleaned with chlorine gas or sodium treatment, it is sent to the bottom of the mercury pot by means of a baffle plate. It then floats up through four inches of mercury, dissolving all the slimes and bubbles, and the tailings are carried off through electrified baffle plates which will catch any values or mercury which might leave the amalgam pot.

In many placer propositions where the sand and gravel is known to contain good values and where the modern dredge yields the operator a small fortune in a short time, the fineness of the gold and the presence of large quantities of magnetic black sand has served to render nil the operation of tables and other methods of securing the values. In passing pay-dirt containing black sand over amalgamating plates or over tables, quicksilver is soon coated and the minerals go over it without being attracted. Once coated the plates are useless until cleaned, only to be quickly recoated again. Here, again, is where the Morrison Amalgamator scores a decided triumph. In removing the magnetism from the sand through treating in chlorine gas or sodium treatment, and the action taking place in the sea of mercury, this sand is separated from the values and floats off, causing every particle of gold coming in direct contact with the quicksilver, as already explained, to be retained underneath because of its greater specific gravity, while the sand seeks its natural level.

It must be plainly evident to any mining man, or to any other man at all familiar with the problems of amalgamation, that this portable machine, which is light and easy to assemble and which requires but three horse-power to operate, combines the necessary qualities of simplicity and effectiveness to make it practical for treating mill products, placer or the products of a dredge. Its simplicity does away with the necessity of skilled labor and at the same time retains the requisites which the actual saving of all values demands.

Not only is the Morrison machine simple to operate but its parts are few and arranged with no complications and without delicate castings liable to break under strain and render the machine valueless where operated far distant from supplies or where repairs are obtained only with greatest difficulty. Importation and operation of the Morrison Amalgamator in a new and rough country does not present a serious problem. In consequence the values may be recovered from any placer or dredge proposition in most remote fields without the aid of modern transportation facilities.

Another very important feature is, this machine does not require the aid of running water in its operation. As the tailings and water are dumped into a sump tank, the water is used over while the tailings are carried off on an endless chain. This is a very important item, especially in dry vicinities.

The machine weighs one thousand (1000) pounds and consists of a centrifugal pump, a gasoline engine which generates the electric current to six volts, furnishing 55 amperes to the U-pipes; the tubes themselves $2\frac{1}{2}$ inches in diameter and $3\frac{1}{2}$ feet long, and mercury pot and baffle plate.

No. 77. Murphey Gold Recovery System. This process is being developed by Seattle parties who stated (October, 1930) that laboratory tests and demonstrations had proved very satisfactory and they were preparing to work on a larger and commercial scale. They were not at that time ready to offer it to the public. The writer has not been advised of any subsequent developments.

No. 78. Parker's Gold-Trap Process. This device for extracting gold from sand and gravel in flowing streams, the invention of J. E. Parker, is being used on a commercial scale by the Parker Process Syndicate at their property on the Vermillion River, Montana.

A detailed description of the process with photos showing the arrangement and construction of the Parker Gold Trap is contained in the Mining Review of Salt Lake City[1] from which the following notes are reproduced:

"The Parker Trap is an arrangement of riffles in the center and steps along the sides of a fan-shaped passage. The water pours into the narrower end of this trap with considerable velocity, which is then slowed down as the trap widens. Over the Hungarian riffles round planks were placed just far enough apart to permit the black sand and the smaller pebbles and nuggets to pass between them. Similar planks are placed across the steps beside the riffle at an oblique angle which causes the ends of the planks toward the center of the trap to point upstream at an angle of about thirty degrees. These halt the fine gold moving swiftly with the stream and propel it toward the center, where the backward suction into the riffles tends to cause still more gold to be deposited in the open spaces under the planks.

"Recoveries are slight in the sets in the flume which were mainly to halt the flow of water and set the gravel and nuggets which it contains to boiling and settling. In the neck of the flume recoveries are a little higher, but the chief values are obtained in the pan, which is four feet across at the upstream end and about ten feet wide at the lower end. The highest gold recovery is and should be made in the second and third riffles from the lower end."

No. 79. Parsons Black Sand Reduction Works. The owner of this plant has had much experience in the handling of gold and platinum-bearing black sand. He has prepared and published a booklet on the subject and is prepared to furnish blue-prints and instructions for constructing a black-sand reduction table at the mine, such as he has used successfully. All necessary instructions for the treatment of the material are included.

No. 80. Pascoe's Dry Placer and Mill Tailing Machine. This is not strictly a 'dry placer' machine as it requires a small amount of water to operate. No description of this apparatus is at hand. The inventor has stated that his machine was used on beach sands with satisfactory results and has submitted a copy of a report made by S. A. Storer in the form of a letter as follows:

"UCLUELET, B. C., April 12, 1923.

To Whom it May Concern:

I have had 35 years experience in placer mining and have worked in California, Arizona and Alaska and have held responsible positions in placer and deep gravel works and happened to locate at the above address and had the pleasure of examining and seeing at work Mr. Burt and Mr. Pascoe's placer mining machine which they are operating on Wreck Beach and I further state that I have seen 30 or 40 different gold saving machines at Nome, Alaska (in 1900), and saw the machine of Messrs. Burt and Pascoe's which is the only one I ever saw that is practical. The machine is so constructed as to use the same water continuously by a system entirely their own. Water passing over the riffles to a sump and is continuously pumped back over the riffles and the only water it uses is the moisture of the sands taken out and evaporation of the sun. The machine they are using here is an 8-inch machine and will handle about 10 tons of dirt in 10 hours but there is no limit to the size. These machines can be constructed to any size desired. The gold is saved

[1] *The Mining Review,* Salt Lake City, Utah, Vol. 30, No. 9. August 15, 1928.

in the ordinary system of sluice boxes. The whole plant is operated with a 3-h.p. gas engine. I spent some time in Arizona, where they use the dry washer and save the gold by blowing the sand through, leaving the gold behind, but any gold the same weight as the sand will be blown over with the sand. The machine in question will save the smallest particles of gold hardly visible to the naked eye.

Respectfully,

(Signed) S. A. STORER."

Patent has been applied for and a patent number assigned the invention.

No. 81. Pierce Gold Separator and Amalgamator (The Gold Gatherer). The following general description of this device is taken from the catalog of The Mine and Smelter Supply Company.

The Pierce gold separator and amalgamator consists of numerous L-shaped copper riffles, which are treated with quicksilver. These are so arranged that the water carrying the pulp or sand sweeps all particles repeatedly against the amalgamated surfaces. The L-shaped bottoms of the riffles also contain quicksilver into which rusty gold will sink by gravity.

Riffles for placer mines and dredges, and for mills differ only in size. The principle and design are identical.

The riffles are made of only the purest and softest, annealed, Lake Superior, or electrolytic copper. They are silver-plated, if desired. They are held in position by riffle-holders which are placed lengthwise of the riffle-box, and on each side of it. There are two sets of holders, one set for the lower riffles, and one for the upper riffles, the latter being placed on top of the former. The holders are grooved strips of wood, the ends of the riffles fitting into the grooves. The riffle-box is made of sheet-iron, and the joints are lapped and riveted to make it water-tight.

The lower riffles (D), are bent somewhat like the letter Z. The top of each riffle is bent back in the direction of the flow of the water, thus allowing an air space to be formed behind the riffle. The bottom of each riffle is turned up at each end and brazed so as to hold a pool of quicksilver.

The upper riffles (C), are placed above the lower riffles, and extended down between them. The tops of these riffles are also bent back in the direction of the flow of the water, while the bottoms are bent toward the flow of the water in such manner as to hold the quicksilver in the bend or L.

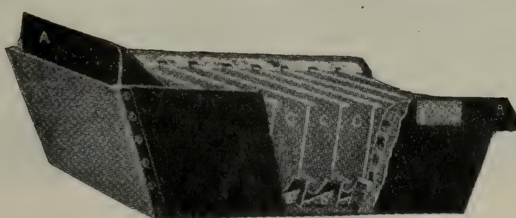
The Pierce gold separator and amalgamator is characterized not only by successful design and excellence of material, but by the extreme care exercised in its construction.

For placer installations one or more sets of V-shaped grizzleys are placed in the bottom of a section of the flume which is then set in the main flume or at the end of it. The bars of the grizzley are set at a slight angle from the flow of the water so that the fine gold, sand, and gravel are gradually brought to the openings and pass through them into the grizzley box. The grizzley box is supported by rods underneath the grizzley and flume. The bottom of the box slants downward in the direction of the flow of water. At the lower end there is a gate which can be regulated to take from the flume only as much water as is necessary to carry or move the gold, sand and gravel that pass through the grizzleys.

The gold, sand and gravel are then taken in a launder, or flumes. to the screen boxes where the coarse gold and fine gravel are separated

from the fine gold and sand. The latter pass through the screens which are adjusted by means of hand-screws so that the discharge end of the screen is higher than the end over which the gravel first passes. Underneath the screen a gate is provided which can be adjusted to admit only the amount of water and sand that the amalgamating boxes and riffles can handle. Thus the water is kept above the screens, expelling the air from beneath them, and the flow of the water carries the fine gravel and coarse gold over them. There is not the tendency for the coarse gold and gravel to settle and stop up the meshes of the screens as is the case when air is allowed underneath them.

The riffle-box is set at an angle of from two to four inches to the foot, depending upon the material to be treated. The fine gold and sand pass through the screen and are then run through the riffles. The pulp flows underneath the upper riffles (C), and over the lower riffles (D). As it passes into the riffle box at (A), it fills to the top of the first upper riffle, and then passes under it and over the first lower riffle; then up between the first and second upper riffles to the top of them, where it looks like muddy water boiling; then down underneath the second upper riffle, up over the second lower riffle, up to the top of the second and third upper riffles, and so on until it passes out at the lower



No. 81. Pierce Amalgamator.

end of the box. The gold either adheres to the riffles or sinks into the pools of quicksilver. The sand and water are thrown out at (B).

The black sand is continuously agitated and thrown out by the water passing down between the lower riffles. And by keeping the fine, or flour gold in the current of the water it is swept against the amalgamated riffles so many times it is impossible for it to escape.

As the coarse gold reaches the pools of quicksilver in the bottom of each of the upper and lower riffles it readily sinks into them, even though it be tarnished or fouled. This by reason of the fact that the specific gravity of gold is 5.8 points greater than that of quicksilver, in addition to the affinity of mercury for gold. Hence all of the gold lost in the ordinary riffle and on mill plates is retrieved in the Pierce.

No. 82. Pierce Gold Dredge Machine. This machine as used at the Jenkins and Taylor Placer, near French Gulch, Shasta County, is described by Logan[1] as follows:

"For washing gravel they have installed a Pierce Gold Machine, which is a small dry-land outfit patterned after one used in the placers near La Panza (San Luis Obispo County), where water is scarce. It carries a trommel about 4 feet by 16 feet with $\frac{3}{4}$-inch screen, through which fine gravel discharges on each side into four apron sluices $2\frac{1}{2}$ feet by 4 feet, thence to 30 feet of sluice $2\frac{1}{2}$ feet wide with Hungarian riffles. Coarse cobbles pass through the lower end of trommel to a bucket elevator with buckets 2 feet wide which is capable of stacking rocks 20 feet high or

[1] Logan, C. A., State Mineralogist's Report XXII, Chapter 2, Mining in California, April, 1926.

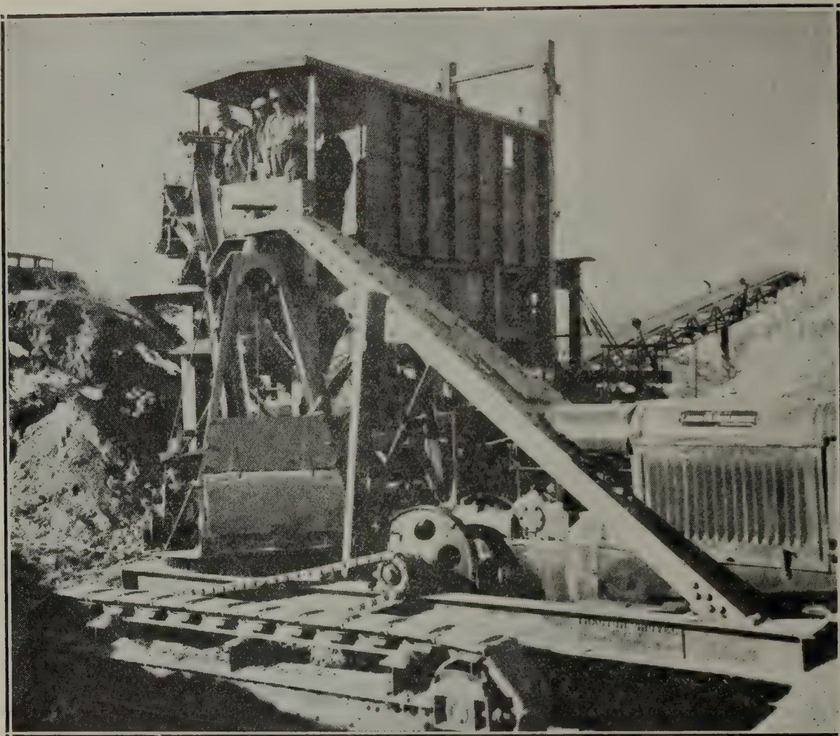


Photo by courtesy of Kern County Chamber of Commerce, Bakersfield, California.

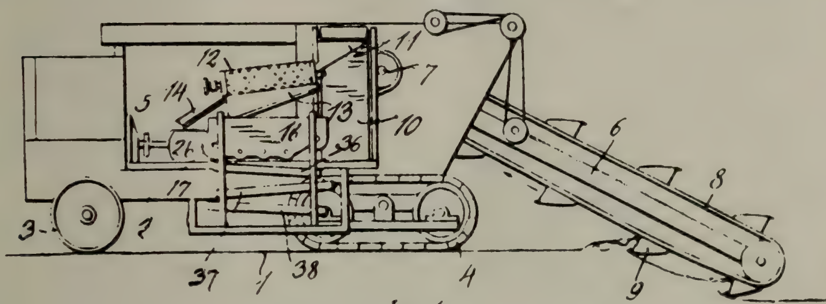
No. 82. Pierce gold washer and amalgamator operating at Randsburg, Kern County.

No. 82. P. & H. gasoline steam shovel and Pierce gravel gold washing machine on Jenkins and Taylor placer, near French Gulch. Photo by courtesy of Clifford Taylor.

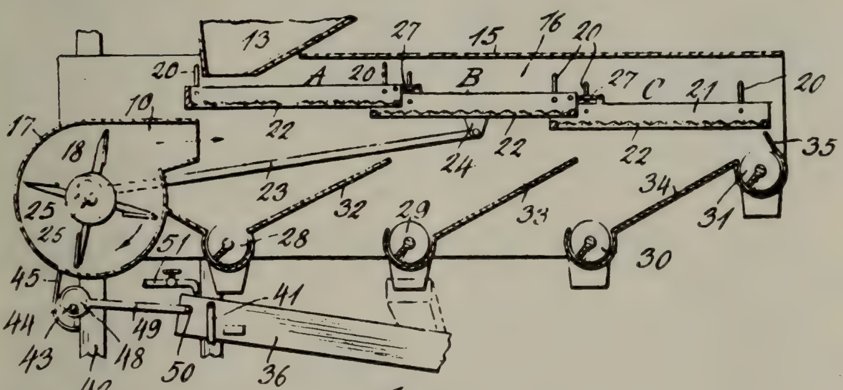
more. In operation this machine is dragged around on skids by the gasoline shovel which feeds gravel into the hopper. Power for the Pierce Machine is furnished by a second-hand automobile engine working through chain and gear drives. A 6-inch centrifugal pump supplies water for washing."

A Pierce Gold Dredge Machine has recently been installed on a property near Randsburg, Kern County. This machine weighs 12 tons and digs to a maximum depth of about 25 feet. It has a capacity of 300 to 400 yards daily and requires 2 men to operate. The cost of operation is said to be about 15 cents a yard exclusive of cost of water.

No. 83. Pilgrim Dry Concentrator. No descriptive matter is at hand concerning this machine. It is manufactured in Los Angeles.



No. 84. Sketch showing general arrangement.



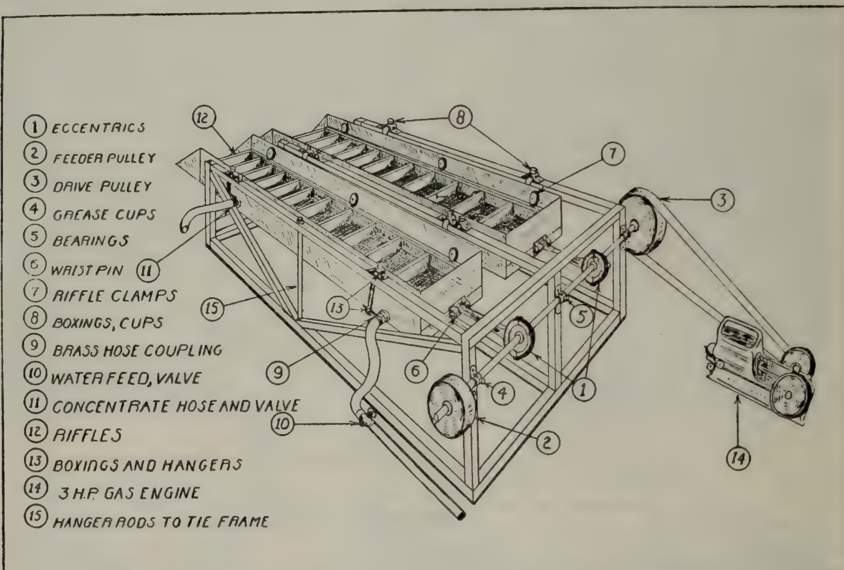
No. 84. Construction detail.

No. 84. Placer Gold Mining Machine Equipment. This company's equipment apparently is that covered by the Thomas Dugan patents. It appears that it can be operated either as a dry washer or combined dry and wet washer. Claim III of the patent reads as follows:

"In a Placer Mining Machine, in combination, a truck, means carried by the front end of the truck for digging and elevating materials, a screen carried by the truck means for transferring the material from the delivery end of the digger to the receiving end of the screen,

a hopper located beneath the screen and adapted to receive the screenings, a separator located beneath the hopper, the separator comprising a sectional screen, means comprising links for suspending the screen, means for reciprocating the screen, means for directing an air current along the bottom of the screen whereby any material passing through the screen will be separated in accordance with its weight, a plurality of transversely extending conveyors located underneath the screen, inclined bottoms for directing materials to the conveyors, a sluice box located underneath the transverse conveyors, and means for reciprocating the sluice boxes and for imparting to them a transverse movement.''

This apparatus is not for sale but owners wish to negotiate for suitable placer ground on which to operate.



No. 86. Ratcliffe Concentrator and Amalgamator.

No. 85. Pollock's Flour Gold Concentrator. U. S. Patent No. 1379417. The following statement is abstracted from a circular issued by the patentee:

"This device is the result of years of experience in South Dakota and Idaho, and 98% of the values may be saved by this device. It is a corrugated and perforated brass riffle placed in a slot cut transverse of the sluice box, with amalgamated copper plate under it, and an eighth to quarter-inch discharges from side of sluice box into tub or box, which will be rich and may then be panned or emptied into head of sluice box. The copper plate may extend a little outside the sluice box and have a handle on it and be changed as often as necessary with very little delay. Every sluice box needs one concentrator and some need two or three. It depends on size of proposition and amount of dirt you are handling."

Price $10 in advance, f. o. b. Sawtelle, California.

No. 86. Ratcliffe Concentrator and Amalgamator. This machine is designed to handle both placer material and crushed ores and is said to have been successfully used on gold, silver, platinum, tin, chrome, manganese and tungsten since 1922. It uses only a small amount of water which may be pumped back and reused and requires only 3 horsepower to operate. The concentrator and amalgamator weighs 300 pounds. An engine will bring the total weight to about 800 pounds or

a Ford car can be jacked up and the engine used to run the machine. The operation is described in a circular as follows:

"In gold we use silvered copper plates, also a quicksilver trap. The machine is simple and easily operated, automatically fed, one ore feeder will take care of two machines. The machine will put through about two tons per hour of gravel or crushed ore—do not classify the product. The construction as follows: The riffle box is made of heavy sheet iron welded together, so there are no rivets to come loose. The box is six feet long, eighteen inches wide and one foot high. Riffles are four and one-half inches high, spaced wide at the feed end and narrow at the discharge end of the riffle box. Under the riffles we have a wooden riffle board in which holes are bored to let the water feed upward and under the riffles. The water comes up under each riffle forced by a gentle and steady flow from a gravity tank above the machine. On top of the riffle board we have a steel screen the holes of which are so fine as to let only the light or small particles of gold or concentrate through. At the bottom we have a chamber about three inches under the riffle board, we also have a silvered copper plate on the bottom covered with quicksilver to amalgamate the gold the same as in any gold mill.

"There is a quicksilver trap to catch any amalgam that might slip off the plate—thus we save all the gold. The inlet for the water is at the front or feed end of the riffle box with a discharge at the lower end where the light concentrates run into a sump. And the slimes that may get down under the riffles will flow over the top of the sump and the heavy concentrates will sink to the bottom of the sump.

"We catch most of the heavy concentrates and gold nuggets between the riffles lodging on top of the metal screen; this is cleaned out from between the riffles two or three times a shift, but we do not have to clean the bottom of the machine only about twice a week, according to the richness of the dirt you run."

Mail has been returned unclaimed from the last known address of the Ratcliffe Concentrator Co. in San Diego, California.

No. 87. Reagan Machine. Mr. J. B. Reagan writes from Kansas that he has a placer mining machine with which he expects to move Wall Street out west. No description of it is at hand.

No. 88. Reagan Process. C. E. Reagan has advised the writer that he and associates successfully worked a beach placer near Crescent City in 1931, in the following manner.

The deposit is on what is known as the Bowers place, and the sand averaged 25 cents per yard for a depth of 12 feet. They used a 4-inch suction pump to pump the sand over two 3-ft. by 24-ft. sluice boxes lined with burlap and metal lath. Another water pump was used, pumping through a nozzle which agitated the sand and fed the suction pump. They were handing 200 yards in 8 hours. The boxes were cleaned once each day and the concentrates re-run through a small sluice box once a week.

This operator is not the party mentioned under No. 79, Reagan Machine.

No. 89. Reeder Fine Gold Saver is a small compact inexpensive machine designed to separate the very fine as well as the coarse gold from gravel.

The machine is adaptable for remote sections where only a very small amount of water is available, as only a minimum amount is needed. The water can even be pumped back from a small reservoir or tank and used over and over.

This machine appeals to the small mine operator as well as the companies operating on a large scale, owing to the low purchase price, the low power cost and the fact that it can be made small enough to be taken anywhere on an auto trailer.

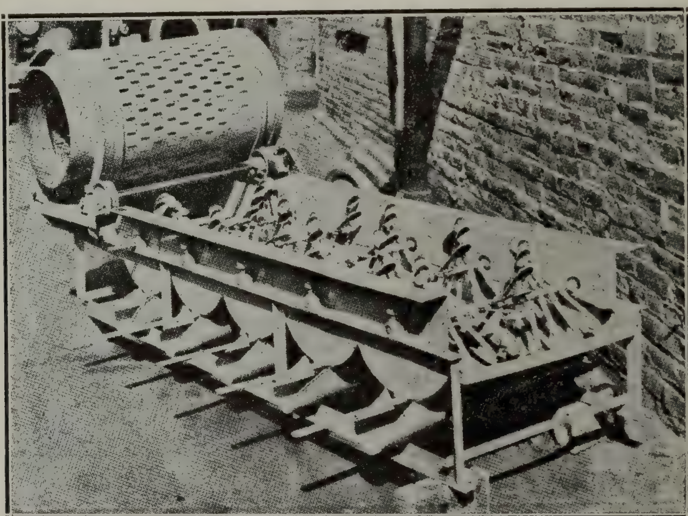
Operating on the American River near Michigan Bluff in the sand and gravel of the river bars, the recovery of fine flake and flour gold is amazing. The Reeder Fine Gold Saver has overcome the bugbear of gravel miners from ages back by its remarkable ability to recover value

from tailings dumps, gravel and sand deposits, hydraulic pits and from river and creek beds where the fine gold is continually moving.

Hydraulic mine owners will find this machine the answer to a long felt want, since hydraulic mining is no longer practical in many sections as at a minimum cost of operation, the fine as well as the coarse gold is saved.

The machine comes equipped with a gasoline engine which will operate at a cost from 25 to 40¢ a day. The machines at the present time are built in different models to handle from 25 to 100 yards of gravel a day. Any other size built to suit your needs or convenience. For larger operations, several units may be placed together.

The price of the model handling from 25 to 40 yds. is $500 net f.o.b. Sacramento. Other sizes in proportion.

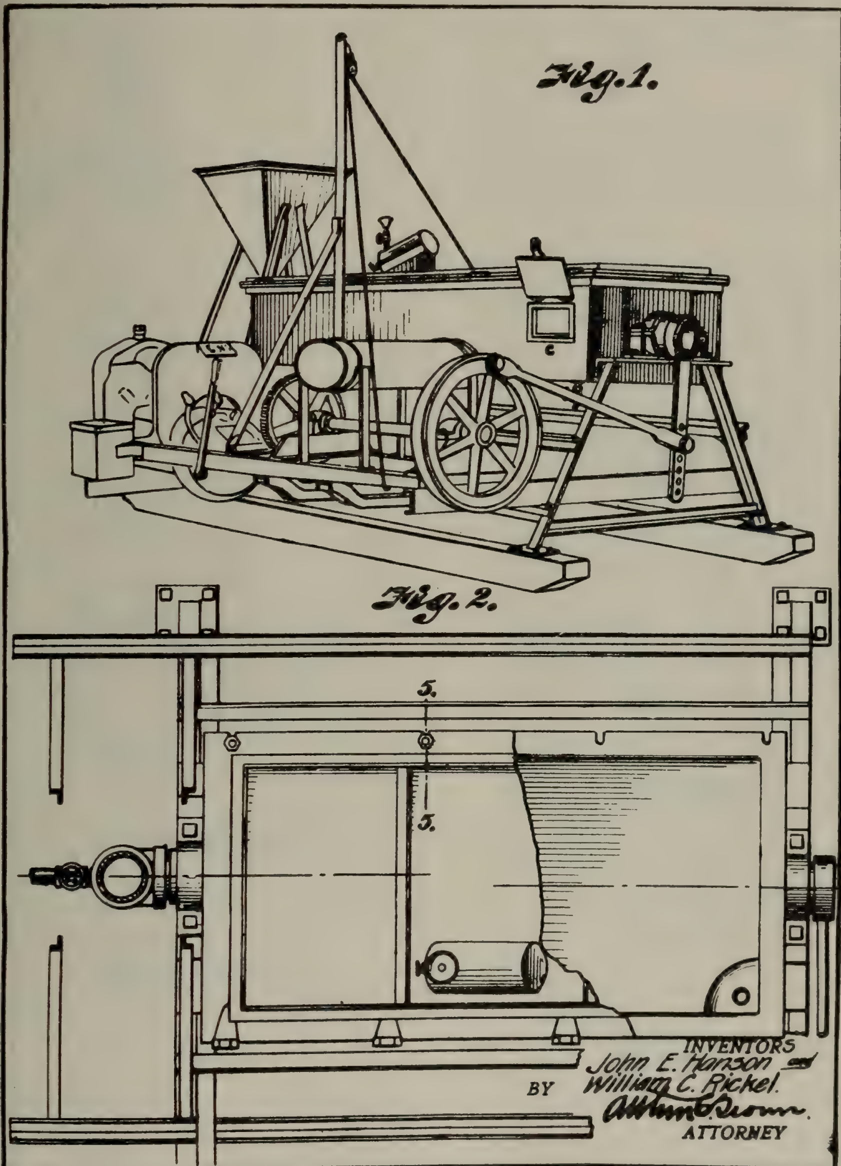


No. 89. Reeder Fine Gold Saver.

No. 90. Rickel and Hanson Gold Reclaimer. Mr. Rickel describes this concentrator and amalgamator as follows:

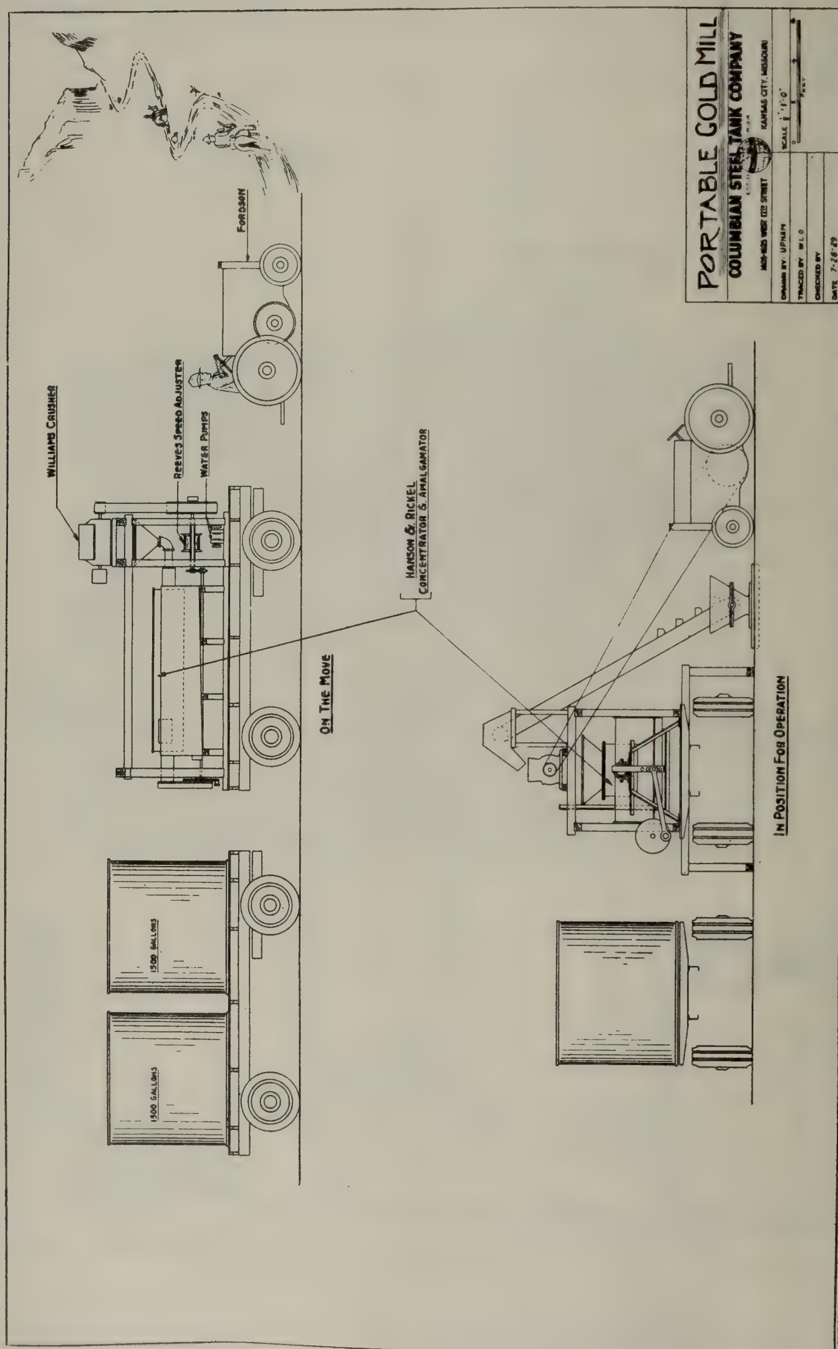
"A box, made of steel boiler plate, approximately 8′ long, 2½′ wide and 18″ deep, with a lid, also made of boiler plate, the box being supported by a pivot at each end, and into one end is a feed from a hopper. At the sides, about 6″ from the bottom and close to the rear end, are openings for the discharge of waste material. The box has three distinct motions—one a jerking motion, another a rocking backward and forward motion, and an elongated motion; I mean by this that the hopper is higher than the other end, which causes the ore to travel downward. This elevation of the box can be adjusted to suit the occasion. The box is lined with copper. Riding on the lid of the box is a device that contains quicksilver, and in this device the quicksilver is gassified, and at intervals we shoot gassifying quicksilver into the box when it is in motion, while the doors are closed, thus making it water-tight. The gassified quicksilver, as soon as it enters the box, condenses and comes in contact with all gold and silver, and either takes it to the bottom and amalgamates it on the

copper lining there, or amalgamates it at the top, sides or ends of the box. In the event the gold and silver are not too fine, we can eliminate the gassifier, concentrate the gold and silver at the bottom of the box, and throw the refuse off.''



No. 90. Rickel and Hanson Gold Reclaimer.

''This machine can easily be transported over mountains, and to other places difficult of accessibility; can be run very economically, and will handle fifty tons of ore per day; or more, according to size. The cost of the machine also will be small, compared with other layout for



No. 90. Rickel and Hanson Portable Gold Mill.

handling gold and silver. The machine will concentrate as many tons as desired, into one ton, thus saving the cost of transportation and smelting charges.''

The accompanying cuts indicate its application to various placer operations. This equipment is manufactured by a Kansas City Company with San Francisco agency. In October, 1930, a demonstration run was made on tailings at the Annie Laurie Mine, Placer County (see *Colfax Record,* Colfax, California Oct. 4, 1930).

No. 91. Root's Apparatus for Amalgamating. U. S. Patent No. 1529038. This invention relates to placer mining and has to do with apparatus for amalgamating gold and other precious metals in passing over a sluice box. The following notes are excerpts from the patent specifications.

Briefly described, the method of amalgamation consists in passing the placer sand and gravel together with water over a still body of liquid mercury whereby the values are extracted by the mercury as the material is floated over the liquid surface, and the apparatus for use therewith consists in certain receptacles for the liquid mercury adapted to be placed in the bottoms of sluice boxes, mill tables, etc., whereby the pool of liquid mercury is presented with a proper working surface to the moving sand and gravel, means is provided to prevent splashing of the mercury by large stones, a reservoir is provided for sinking of the amalgam, and an opening is provided in the reservoir for the removal of the amalgam without disturbing the setting of the apparatus in the sluice box; also other features are incorporated such as means for forming a tight connection between the receptacle and the bottom of the sluice box, easy renewal of the anti-splash features to provide for wear, etc.

In its preferred form this receptacle consists of a section of pipe of about two inches in diameter and having an opening or slot formed in one side with an upstanding wall of metal welded to the pipe all around the opening and flanged on both long edges. The pipe is closed or capped at both ends and at one end extends a short distance beyond the wall, so that the cap will be accessible for unscrewing and so that a wrench may also be applied to the pipe to steady it if desired.

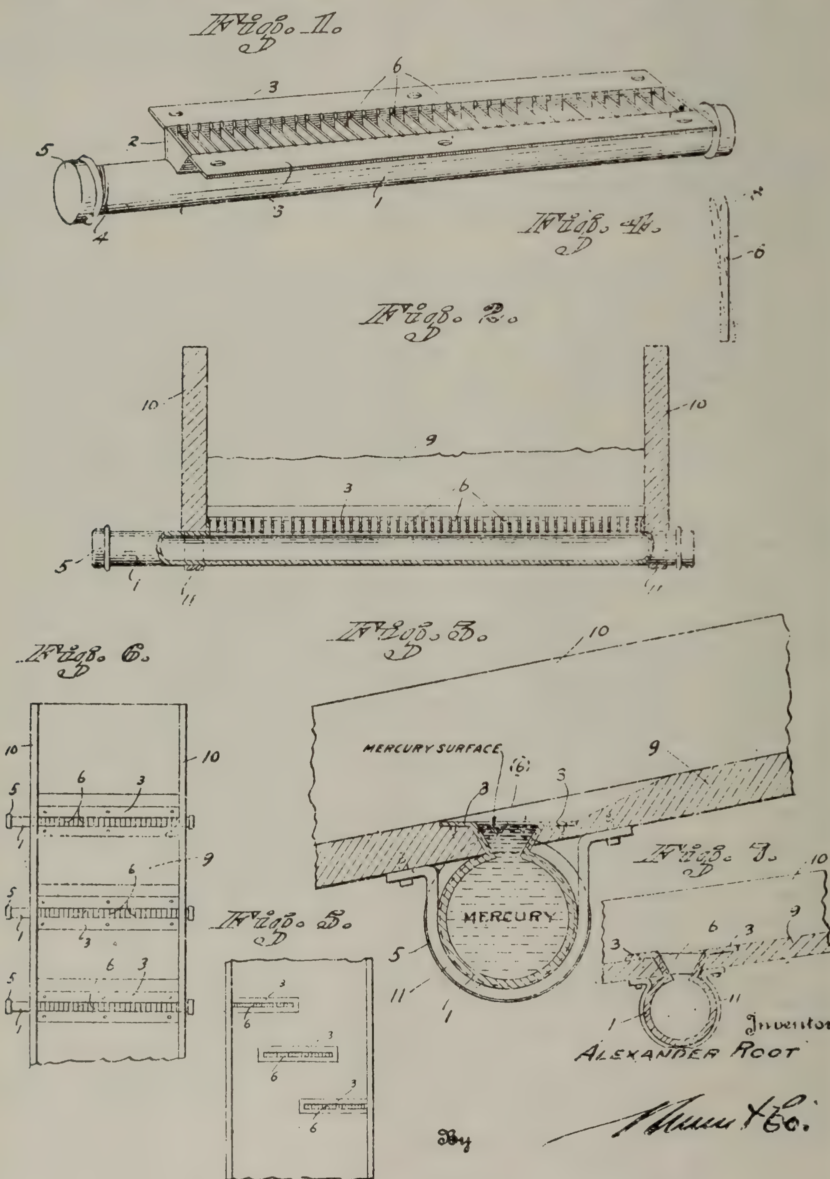
The walls are preferably at a slight angle and form a sort of chute about 2 inches wide on top, leading to the interior of the pipe and transversely arranged. In this chute is a number of spaced plates or grate bars to form a screen over the chute opening.

Any form of grate or screen may be used over the opening but plates are preferred as they are easily inserted in grooves formed in the long walls or in a separate piece attached thereto.

The bars are bent or twisted a trifle as denoted by the dotted lines in Fig. 4 or else the opposite grooves are not quite parallel, so that the plates will fit tightly into the grooves and will not float out when the receptacle is filled with mercury.

The bars or plates are of iron or steel about one-sixteenth of an inch in thickness and preferably brought to a narrower edge on top and when all are in place they are about a half-inch apart and present a grate bar or screen about three-eighths of an inch below the upper edge of the chute. The receptacle is set in the bottom of the sluice box, the flanges being unequally set in the wood on account of the pitch of the box, so as to present a level surface to the upper edges of

the chute, and the flanges are cemented and screwed or bolted to the bottom of the box to make a tight joint, while the ends are similarly cemented and form a tight joint with the sides of the box, and it is



No. 91. Root's Apparatus for Amalgamating.

also desirable that the receptacle be additionally supported by straps passing around the pipe and bolted or lagged to the sides of the box.

In operation the receptacles are filled with mercury to within about one-sixteenth of an inch of the upper edge, and the sand, gravel and

water is run over the sluice in the usual way and when the material strikes the clear pool of mercury above the grate bars it is simply floated across by the rushing water and discharged over the far edge of the chute, thus applying a bath of liquid mercury to the moving material for amalgamation of its precious metal content.

The grate bars provide a support for the larger stones, thus preventing splashing of the mercury, though in case of treating reduced material or pulp the grate could be dispensed with. The upper edges of the bars are as thin as practicable to reduce the surface to which any amalgam can adhere or pile up on to be carried out of the chute by the moving gravel, and being vertically arranged, permit sinking of the amalgam to the lower part of the receptacle, thus always presenting a clean surface of mercury for the treating of the oncoming material. By thus treating the moving material on a pool of still mercury flouring and loss of mercury is entirely avoided and the grate bars prevent physical loss through splashing from large stones, also prevent large stones from engaging the leaving edge of the receptacle thus insuring their constant downward travel.

To remove the amalgam it is merely necessary to remove the cap from the pipe and take it from the open end of the pipe, and if very thick a few of the bars may be removed and the amalgam pushed out from above. In this connection it is evident that the grate bars may be all secured together like any grate, but if separate as shown it provides for removal or changing around of those most worn.

Where a series of receptacles is used any one at a time may be emptied without stopping the flow of material by simply sliding an iron cover on top of the open chute and allowing the material to pass over it until the receptacle has been emptied and refilled with mercury. Any sand or gravel getting into the receptacle will of course float out again when the receptacle is filled with mercury.

No. 92. Rose Gold Placer Machine is referred to by the manufacturers as "the invention of the age." It is briefly advertised in a circular in part as follows:

Now comes a concentrator which revolutionizes the mining of precious metals. It is patented, owned and controlled by the Rose Gold Concentrator, Inc., and briefly it is described as follows:

It is constructed of iron and steel, and can be made in various sizes to suit the condition of operation.

Mining men from all sections are amazed by its wonderful, almost unbelievable work. This machine is 25 feet in length, 4 feet wide and 4 feet high. The tank of the machine holding the earth is watertight, set on a pitch of 5 per cent. The bottom of the tank is made of V-shaped troughs, and on the ridges of these troughs are compressed air pipes.

The tank rests upon rollers, which, when in operation, gives it a forward and backward movement, together with a twisting sideways and up and down movement.

A ten horse-power engine furnishes adequate power, which is transmitted to the machine by a pair of eccentrics. The tank of the machine is about half filled with water, together with the earth from which the metals are extracted.

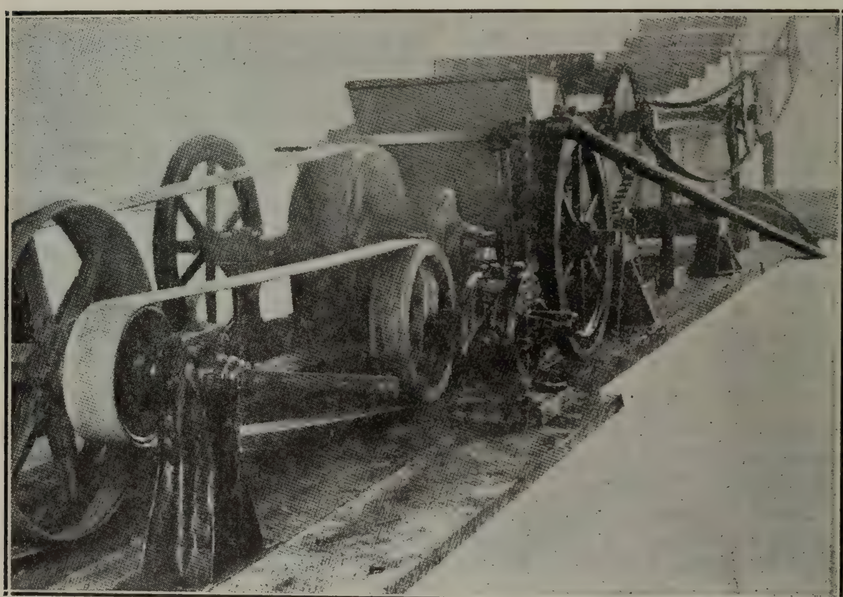
The movement described above is helped with drag chains which carry the material to the rear or lower part of the machine; with the

help of the compressed air attachment, the chains keep the earth from packing.

All metals because of their specific gravity go to the bottom and are caught in an ore pan and the waste matter is carried out of the tank by a set of drag bars, the ore being drawn off by an ore valve. Bear this fact in mind: The water in the tank remains stationary, and therefore the machine can be operated in a section where there is very little or no water, the small amount necessary being easily supplied by any conveyance.

A careful study of the above will give you a mental picture of the machine in operation. The principle of operation is that of a miner panning, only here it is done on an enormous scale.

Placer mining up to the present time has been conducted the same for the past twenty-five years and more. There are many methods



No. 92. Rose Gold Placer Machine.

which now all pass into the discard with the coming of this wonderful concentrator. The old methods all required much water, making mining in a dry section almost impossible, and even where water was to be had most of the values were lost. But under the old methods millions of dollars have been made, as every one knows, poor men have grown rich and rich men have become tremendously wealthy.

An example of prospective earnings:

A medium sized machine will easily handle on an average 15 tons of sand and gravel per hour. Much of the placer properties contain values running to $10 per ton, but as a conservative estimate we will take for example, gravel running one dollar to the ton. The machine will in a 24-hour day handle 360 tons, or 108,000 tons per year, or bring in returns to total $108,000. That is one machine.

For centuries the mining industry has sought to perfect a machine that would save the precious metals of the earth, and that such a machine is now a reality means the dawn of a new era in the world's mining.

No. 93. Rotary Concentrator and Amalgamator. A bowl-shaped rotary concentrator and amalgamator for ores and fine placer gold which was in the development stage when brought to the attention of the writer. No later information has been supplied.

No. 94. Rosseau Centrifugal Gold Washer. Patent No. 1478761. Geo. E. C. Rousseau, inventor. This machine is apparently intended for the concentration of free and base ores only, as no mention is made in printed matter of its adaptability to placer operations.

Present address of company in doubt.

No. 95. Rusch Machine Separation Processes. This company is developing two distinct types of machine separations. One is an improved *Sutton, Steel and Steel* (see, *post*) process designed to handle heavy black sand and ores broken down to the proper mesh. The other type of machine which has been developed over a period of four years, will separate material by shape of particle and should work on light gold or flake gold. Descriptive matter will be sent to inquirers by the makers as soon as prepared and there will be a representation on this coast. Manufactured in the east.

No. 96. Savage Fine Gold Saver. W. B. Savage is listed as having a fine-gold saver for placer gravel. Details are lacking, but can probably be obtained by communicating with Mr. Savage.

No. 97. Schaefer Apparatus. This apparatus consists of a specially prepared 8-inch or 10-inch pipe line and accessories, laid diagonally across a river bed known to carry gold. It is especially suitable below operating mines or at junctions of creeks that bring down gold during heavy rains. The inventor states that installation of this apparatus will not exceed $2,500 in fairly accessible places and that many locations can be so equipped that not one speck will escape, including 'flour' gold.

No. 98. Semi-Dry Placer Concentrator. A machine manufactured in Denver said to operate on 5 to 6 gallons of water per minute and to recover 95% of coarse and fine gold with 50 tons per day capacity. Further data will have to be obtained from the manufacturer.

No. 99. Service Ore Treating and Amalgamating Machine. This machine is described by the manufacturer as a deslimer, steam sterilizer, amalgamator, classifier and scourer. It is designed to handle material both mill pulp and placer, minus ¼-inch mesh.

The method of treatment is given as follows:

"The pulp or ground ore is fed to a hopper in the upper part of the machine from which it is passed to a washing chamber where it receives a scrubbing, from the washing chamber it is passed to a vacuum chamber where the pulp is put under vacuum which causes disintegration to take place, from the vacuum chamber the pulp is passed to the eight steam pressure tubes where it is steam sterilized, scoured, heated, washed with hot water and metallics contained in the pulp ore prepared for amalgamation. The pulp is then passed to a baffle screen where primary classifying is done. It is then passed over a riffle-baffle plate, for spreading and distributing evenly to the mercury bath. The pulp is then passed over a bath of heated mercury where the amalgamation of metals takes place. From here the whole mass is passed to the classifying apparatus where the slimes and a large part of the gangue is

separated from the pulp. The slimes, gangue and classified material all being separated and discharged from the machine at different points. The classifying is done by the use of vacuum and pressure.

"In the treatment of placer, material is passed through the same as ground ore or lode ores. This machine will amalgamate your finest gold, very coarse gold being caught in the trap on the inside of the machine, which is equipped with five of these traps. It will separate gold from black sands where the gold is free; it will separate platinum and osmiridium from the gold so that the gold can be taken from one chamber and the platinum and osmiridium from another."

Numerous other claims are made for this machine in a circular, where it is further referred to as 'one great combination of brains and science.'

No. 100. Sherwood Process. A chemical method of recovering platinum on a small scale from black-sand concentrate has been developed by A. H. Sherwood and used for several years. Logan[1] refers to it as follows:

A. H. Sherwood of Oroville has for several years used a chemical method for recovering platinum on a small scale from black-sand concentrate. His process consists of two stages, (1) putting the mercury and platinum in condition to amalgamate, and amalgamating them; (2) separating the amalgamated gold and platinum. A patent has been granted him for the second stage, but not as yet for the initial process. As his rights have not been clearly defined, it is not thought advisable to fully describe the process. It is a new application of a well-known law of chemical solutions, and appears to do all that is claimed for it, giving a beautifully clean platinum and a perfect recovery which would be impossible by purely mechanical means.

The process has not been perfected to the point where it can be used on a large scale, but this is because of the lack of apparatus and not because of any defect in the method.

No. 101. Smith Patented Washer, for treating sand, gravel or clay for the purpose of removing particles of precious metal therefrom. The accompanying drawing shows the main features of the washer. It is mounted on a frame provided with wheels so it may be moved from place to place. According to the patent specifications the operation of the device is as follows:

Assuming that the parts are all arranged in operative position, dirt is placed in the hopper (47), the motor (51) started with the result that this dirt is conveyed upwardly by the conveyor (48) and dumped into the hopper (57). This dirt falls into the tank (5) and is mixed with water from the spray (62) furnished by the tank (61). The paddles (13) in revolving cause the dirt to be agitated and completely broken up so as to be mixed with the water, and as soon as the puddle thus formed reaches a level of the discharge opening (26) it will pass therethrough and into the funnel (27), at which point it will be mixed with more water from the spray (63), and on to the screen (28).

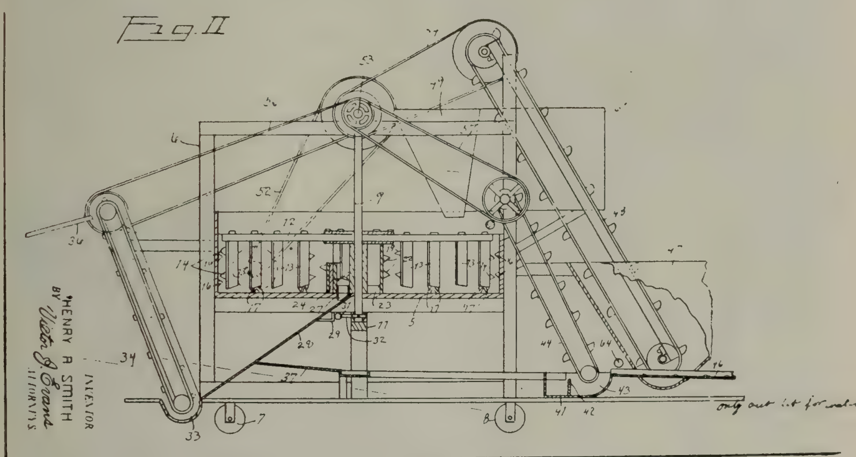
As the shaft (9), which forms the striker, strikes the striker plate (29) thus vibrating the screen (28), dirt which is too large for the screen will pass downwardly and into the trough (33), from which point it will be conveyed away from the machine by the conveyor (34). The material which passes through the screen (28) will fall upon the pan (37) and will wash into the riffles (38) and (39). When this

[1] Logan, C. A., Platinum and Allied Metals in California, State Mining Bureau Bulletin, No. 85, 1918, p. 98.

material has reached the end of the riffles the heavier gold will have been cut by the riffles and the mercury contained therein, while the sand and other foreign substances will reach the sump (41) where the settling action will take place. The sand will thus be retained at this point, while the excess water will pass over the partition (42) and into the sump (43).

The conveyor (44) having buckets thereon will return the water from this point back into the tank. There will, of course, be some excess water which will flow over the sluice (46), but the rate of flow will be so slow, that any fine particles of gold will sink and thus be retained.

It will be also noted that a spray (64) is adapted to discharge into the sluice (46) with the result that the slight excess of water flowing thereover will be further diluted, so as to produce practically a clear water, this action resulting in the depositing of the remaining fine gold. In the treatment of black sand, the sliding gate (24) is removed and a



No. 101. Smith Gold Washer.

lower gate placed therein, because in the treatment of black sand the puddle in the tank should not be over two inches deep.

It will thus be seen that there is provided a concentrator which will handle the coarse, as well as the fine particles, and, that the device might also be employed with other metals.

No. 102. Stebbins Dry Concentrators and Separators. Several types of Stebbins dry tables have been in successful commercial use for over ten years. They are designed to treat free-milling gold ores, lead-silver sulphides and carbonates, copper, chalcopyrite, chalcocite, bornite, placer gold, platinum, tungsten, black sand, and various nonmetallic minerals and byproducts.

The Stebbins dry placer table is used preferably on gravel which has been screened to ½-inch or finer but will handle as coarse as 1-inch if required. Black sands are said to be an aid rather than a hindrance. It is delivered as a concentrate in the ordinary course of operations and

can be saved for special treatment or discarded as desired. The concentrators will handle feed containing a reasonable amount of moisture, usually any material that is dry enough to screen. In installations of

No. 102. Stebbins Dry Concentrator No. 4.

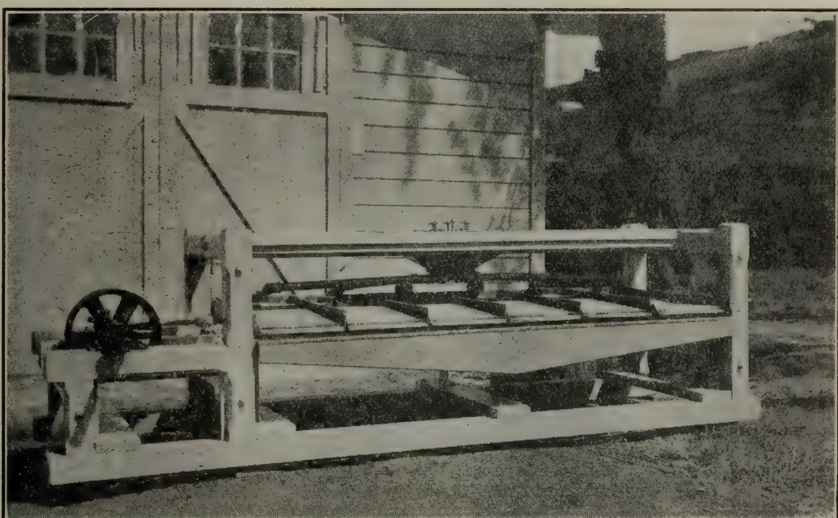
any size provision is made to control the dust and if it contains values to recover them.

These dry tables have been operated in Arizona, California, Nevada and Mexico and returns from all sizes throughout are said to show a general average of above 90% savings of the gold values in a free state

in the gravels. The machines are built to stand up under years of service and being practically automatic in operation require little attention. They are built in a number of models and in sizes from No. 4, having a capacity of 2 tons of screened gravel per hour to No. 12 with a capacity of 25 tons. A recent development is the adoption of the Stebbins machines for the concentration of colemanite and kernite by the Pacific Coast Borax Company.

No. 103. Stephan Machine. See *No. 31. Esco Mining Machine.*

No. 104. Straub Black Sand and Placer Machine. This machine consists of from one to six monel metal riffle trays mounted in a frame as shown in the photo (six tray size). These trays are adjustable for slope and are given a rapid transverse movement by an eccentric, adjustable from zero to maximum, on the drive shaft. The latter is driven at 350 r. p. m. This motion causes a boiling action in the pulp or sands



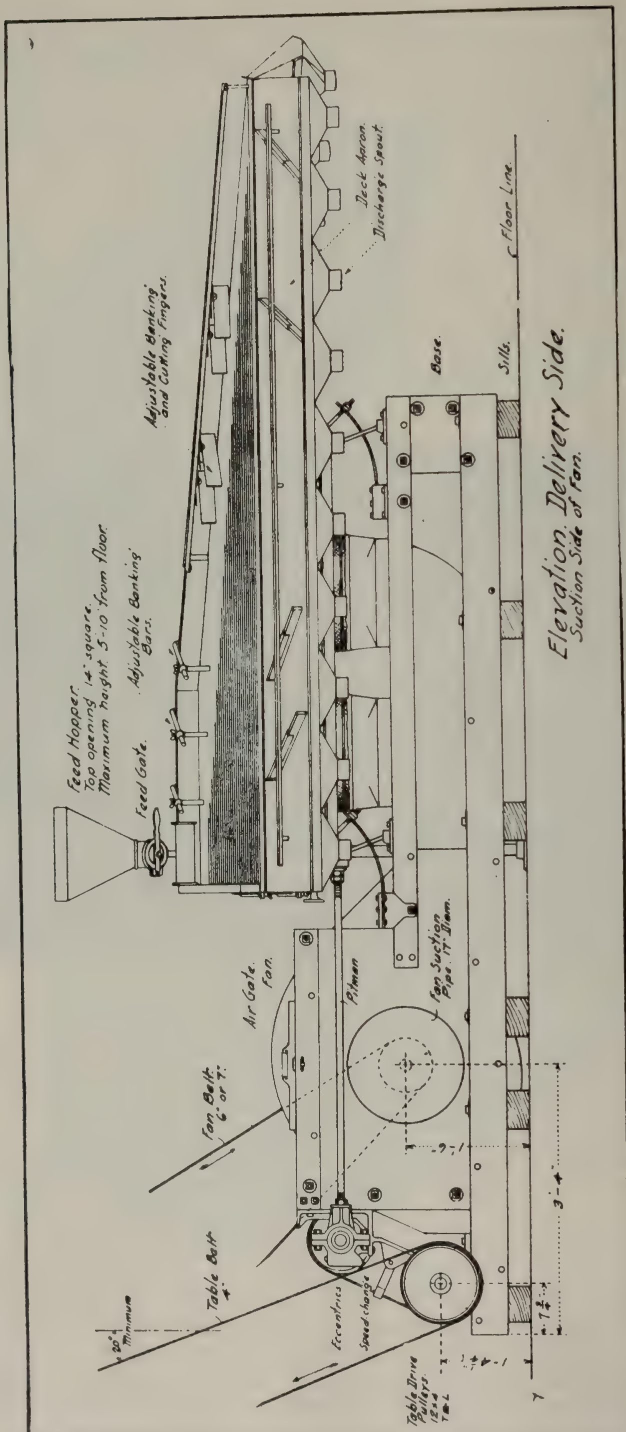
No. 104. Straub Black Sand and Placer Machine. 50-ton size.

between the deep riffles so there is no packing and the fine gold can readily settle through the loose mass of black sand. Mercury may be used if desired but this is seldom necessary as a very high extraction can be obtained by the action of gravity alone.

The capacity of the machine is approximately 8 tons per 24 hours for each tray. Very little power is required, from $\frac{1}{6}$ to 1 horsepower being ample. It works well with a small amount of water, the amount of water used within certain limits not perceptibly affecting the recovery. The machine will handle mill pulp or placer sands, the feed recommended being 8 mesh or finer. Trays are removable for cleaning up. The single tray machine weighs about 250 pounds, and the six tray size about 500 pounds making it readily portable.

The U. S. Mint uses this machine in cleaning up and concentrating floor sweepings, ashes, old crushed crucibles, etc.

The company also manufacture a general line of mining machinery.



No. 106. Sutton, Steele and Steele Dry Concentrating Table.

No. 105. Struckie Process. This party claims to have a flour-gold saving process which will recover 99% of the values. No details concerning this process are known to the writer.

No. 106. The Sutton, Steele and Steele Dry Concentrating Table. This machine was originally developed for the cleaning of seeds, but it has been adapted to the concentration of finely divided ores and minerals with considerable success. Whether it is suitable for the treatment of heavy black sands seems to be undetermined as yet but it may have possibilities.

Tests made from a total of 84 assays while a carload of concentrates was being turned out on a Sutton, Steele and Steele dry concentrator table at a mill in Utah showed an average recovery of lead contained in heads of 92.77% (galena and lead carbonate ore). Average assay of tails 0.8% lead. Concentrate produced per hour 530 lbs. (all sizes mixed). Heads treated per hour 3181 lbs. (all sizes mixed).

No. 107. Taber Amalgamator, is manufactured by Centripact Machinery Co. No descriptive matter concerning this device is at hand.

No. 108. The Tellam Dry Concentrator, was formerly put out by the Denver Engineering Works. This company's patterns, drawings and good will have been acquired by the Stearns-Roger Manufacturing Co., but the manufacture and sale of the Tellam dry concentrator has been discontinued by the latter company.

No. 109. Thiebault Gold Amalgamator is designed entirely upon a new principle which brings the finest gold into positive contact with clean amalgamated surfaces, subjected to a slight pressure, and without the aid of any mechanical power.

It also retains the gold amalgam under lock and key, permits the removal of the plate when loaded with gold amalgam, and requires very little attention when in operation.

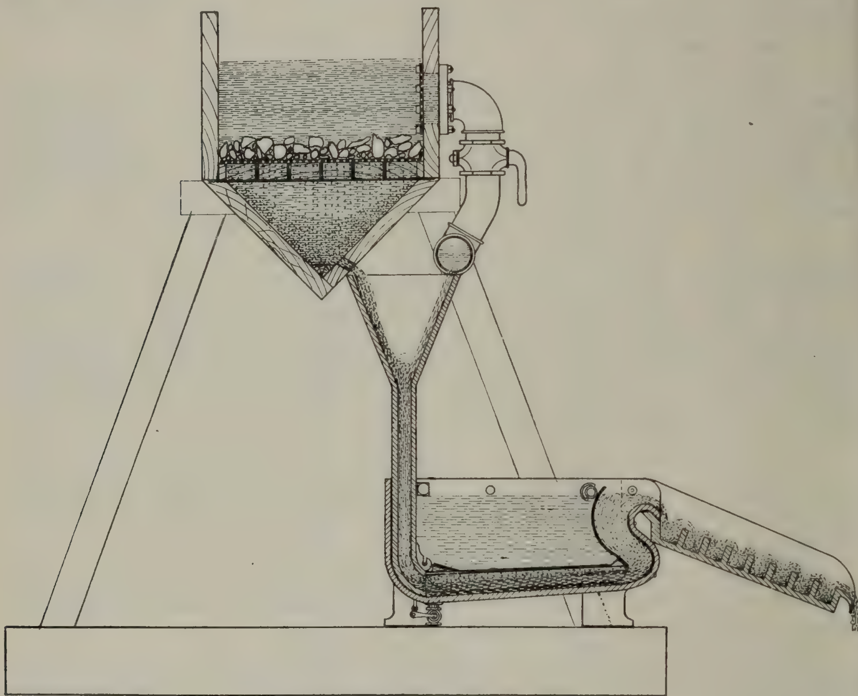
This amalgamator is built entirely of cast iron and copper, mainly composed of only four parts; this insures strength, wearing qualities and simplicity. The new principle used brings the material treated firmly against amalgamated surfaces which are constantly cleaned by the light scouring action set up by the sands as they pass between the plate and quicksilver. It requires no mechanical power and but very little attention to keep it in operation, and the gold amalgam can be kept under lock and key.

The spout, an iron casting with an elongated opening for the passage of gold-bearing material mixed with water, receiving at the upper or hopper-shaped end and delivering to the underside of an inverted amalgamated plate. The spout collects the stream of moving material and delivers it to the surface of a shallow pool of quicksilver until the volume within the spout reaches a height sufficient to force the quicksilver away and permit the stream to flow between the quicksilver and the amalgamated plate, then up through the tortuous passage and over the spillway.

Descending within the spout, this volume of gold-bearing material and water expels the air which very often surrounds the fine grains of gold: this eliminates one of the detriments to amalgamation. It delivers the material subjected to a slight pressure directly against the amalgamated surfaces, thus forcing amalgamation upon the gold. A scouring

action is also created by the sands being forced between the plate and the quicksilver; this has proven essential in keeping the surfaces clean and bright.

Gold and platinum being heavier than the quicksilver, gravitate to the bottom, while the lighter materials are kept afloat of the quicksilver and washed out with the exception of the lightest gold, which has been



No. 109. Thiebault Gold Amalgamator, showing construction details.

forced into amalgamation and is firmly held onto the plate, and the fine grains of quartz which contain small specks of gold attached. This gold amalgamates with the quicksilver and this added weight retains the quartz floating upon the surface of the quicksilver, the current of the stream not being strong enough to lift it out.

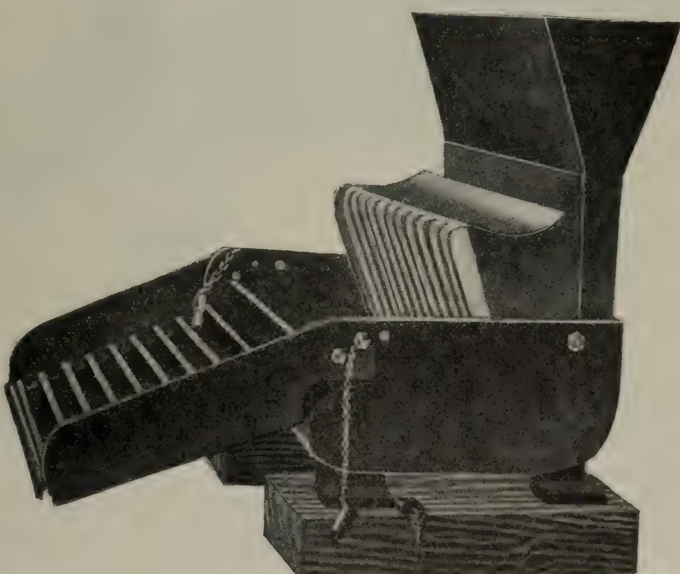
The basin, an iron casting shaped to receive the discharge end of the spout and provided with lugs and bolts to hold the spout rigid. The bottom of this basin is shaped to contain the pool of quicksilver into which the ribs of the inverted plate extend; a drainage is placed at the lowest point and means for locking the drain cock is provided. The front wall of this basin is made somewhat in the shape of the letter 'S,' partly lined with a piece of amalgamated sheet copper; this is to catch and collect all the little particles of gold or quicksilver coming in contact with it as well as to deflect the stream to aid the heavy particles to gravitate and to bring the flaky gold against these amalgamated surfaces. The partition, which is also amalgamated, is next to deflect the stream in the direction of the spillway.

The plate, as the cut below shows, is somewhat improved over the ordinary mill plate. The amalgamation takes place on its under side and in this position it is not susceptible to catching or holding any foreign matter which would be detrimental to amalgamation. At one edge the plate is pivotally connected with the lower end of the spout section, their adjoining surfaces are planed smooth and true, the other edge is free to be held either up or down.

Ribs spaced a little over an inch apart, and parallel with the stream, extend from the under surface of this plate down into the pool of quicksilver. These ribs fulfill three fuctions: (1st) They increase the amalgamating area; (2d) through the aid of the chemical affinity quicksilver has for itself, they draw sufficient quicksilver up to the plate to keep it 'wet' at all times regardless of the scouring action going on by the sands which pass it under pressure; (3d) they prevent any diagonal currents beneath the plate.

The partition or baffle plate is affixed to the free end of the plate to hold it down against the stream while working. It is made from sheet copper and amalgamated to catch what gold may come in contact with it. This partition prevents any great accumulation of sands on top of the plate; also serves to direct the moving stream toward the spillway.

Lock pins one at each end of the partition pass through holes in the sides of the basin and serve to hold the plate down. They also can



No. 109. Thiebault Amalgamator with plate raised for inspection.

be used to hold the plate up to permit inspection of the underside. These pins are provided with a hole in the point for the insertion of a padlock to prevent the opening of the basin by unauthorized persons.

The riffle, a section made of cast iron, is placed just below the spillway as a precaution against the loss of quicksilver or amalgam. Quicksilver is sometimes splashed out if the plate be suddenly dropped

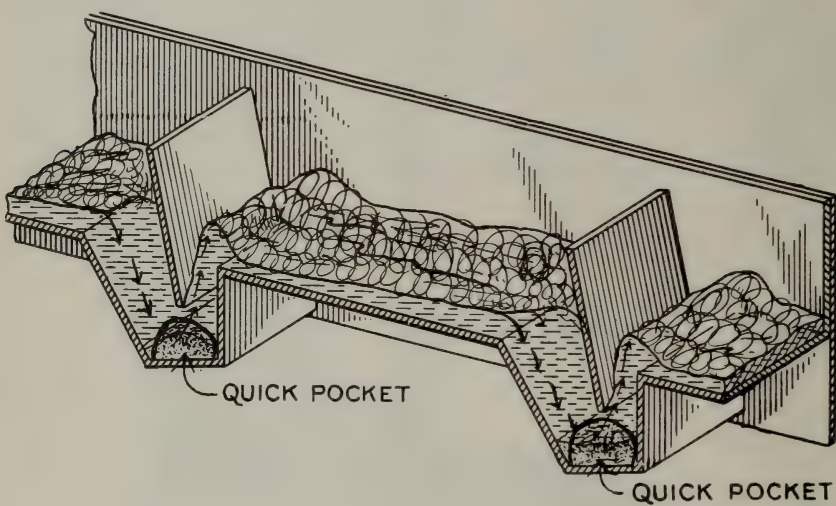
from the elevated position, or if an overcharge be placed in the basin and the feed opened too wide.

To aid amalgamation in cold climates or in winter weather, the temperature of the quicksilver can be raised by applying heat to the under side of the basin.

There is no reason why the finest and most flaky gold can not be amalgamated as readily as coarser gold if it is brought into firm contact with clean amalgamated surfaces. This amalgamator insures this contact and yet does not agitate the quicksilver, for the stream passes over its surface.

This machine is built in two sizes and of either sheet steel or cast iron. Tests on black sand concentrates with first machine built showed a saving of 96–97%.

Mr. Thiebault states that he will work with and assist any purchasers in their mining operations. Price F.O.B. San Francisco, $200 (small size).



No. 110. Cut section of Victory Amalgamator.

No. 110. Victory Riffle-Baffle Amalgamator, is a shallow, flat-bottomed riffle box of special rust and acid proof metal 20 inches wide by 48 inches long, in the twenty-five ton size, and 28 inches wide by 68 inches long in the fifty-ton capacity amalgamator.

Fifteen depressed quicksilver-containing troughs, or pockets, cross it transversely at regular intervals. Suspended over each trough and extending its full length is a metal baffle plate or dam whose lower edge extends down into the trough within a short space of the mercury.

In milling practice the pulp backed up by the first baffle plate, jets down upon the mercury below it. Passing under the baffle plate it rises in an arc and again jets down on the mercury in the second pocket. This action is repeated fifteen times in passing through the amalgamator. It is stated that heavy particles such as platinum or rusty gold that will not amalgamate, nevertheless shoot to the bottom of the quicksilver and remain. For gravel mines, dredging and all

forms of placer mining the amalgamator is made in a modified form which it is claimed will save the finest float gold and yet clear itself of black sands.

No. 111. Wentz Machine. This party claims to have a so-called 'dry' placer machine, which uses very little water. Its capacity is said to be 10 to 12 yards in 8 hours. Details are not available.

No. 112. Wertenberger New Type Gold Saver. Details are not at hand concerning this machine. It is made in Spokane, Wash.

No. 113. Wharton Black Sand Process. A secret amalgamation process for the amalgamation of gold and platinum. Amalgamation is done under cover of a secret solution in special equipment.

No. 114. Whitten Process. This process for separating gold from black sand was developed by A. S. Whitten and used at the Rainbow's End Placer Mines. Details concerning the apparatus or method used are not available except from the inventor.

No. 117. Wright and Mispley Gold Panning Machine.

No. 115. Windemere Process. Said to be a new process for saving gold. Further information is lacking but will probably be supplied by the originator.

No. 116. Winstanley Amalgamator. Listed as a fine-gold amalgamator. Nothing is known concerning this machine, but it is presumed details can be obtained from Mr. Winstanley.

No. 117. Wright and Mispley Gold Panning Machine. It is reported that this new type panning machine at a test made recently on a ranch four miles northeast of Lincoln on tailings and ravine gravels mined in 1850, in a four-hour run, caught gold from the size of the head of a match to half that of a pin, and also black sand of good value, which old-timers could not catch with their crude methods.

The cost of operation was 11 cents for gas and oils and wear and tear on the machine. Amount handled was approximately 6000 pounds. To handle this amount by old-time methods would have taken several days.

The new machine is constructed of steel and weighs 700 pounds assembled. It takes down into four sections, the heaviest of which weighs 300 pounds. It is constructed so as to use the same water over and over, and has a conveyor to carry away screenings of no value.

The machine is powered by a 4-cycle 3-horsepower Briggs-Stratton air-cooled gasoline engine.

The inventors say it is very easy to clean up values in a few minutes, due to the construction of the screening arrangement.

MISCELLANEOUS PLACER MACHINE OPERATIONS

Several river mining operations with small dredges and special gold recovery equipment are described and illustrated in Engineering

Photo by courtesy of Kern County Chamber of Commerce, Bakersfield, California.

Steam shovel and gold dredger working gravel at Keyesville, Kern County.

and Mining Journal, New York, issues of April 20, 1929, pages 628-629; September 21, 1929, page 473; October 12, 1929, pages 581-582.

A description by Frank J. Carter, of a traveling dry-land dredge and gold gravel washer, capable of removing and washing 2000 cubic yards of gravel a day was published in the San Francisco *Bulletin,* issue of April 6, 1929.

The semi-dredging plant of Great Bend Corporation, said to be the only one of its kind in the world, operating along the banks of the American River at Coloma and Lotus is described in the *Placerville Republican,* Placerville, Calif., August 24, 1931, issue.

The *Bakersfield Californian*, Friday, January 1, 1932, devotes an entire page to illustrations and descriptions of various, dry, semi-dry and wet placer mining machines operating in the Randsburg district, Kern Co. Also in *California Mining Journal*, Nevada City, Calif., January, 1932.

A large dry placer dredge for the Panamint Mining Co., located near Ballarat, is described in the *Verde Valley Times*, Blythe, Calif., December 31, 1931, issue.

A new suction gold dredger on the Klamath River at the mouth of Horse Creek, 4 miles below Oak Bar, is described in the *Yreka News*, Yreka, Calif., July 19, 1931, issue.

BIBLIOGRAPHY

An extensive selected bibliography on placer mining is given in an accompanying article by Herbert Franke.

BLACK SAND RECOVERY

The statement, though literally true, that "there are millions of tons of black sand on the beaches of California containing gold, platinum and other valuable metals and minerals" has caused much waste of energy and money in vain attempts to work them on a large scale.

Black sands have been investigated from many angles and over a long period of years: for their gold content; for their contained platinum-group metals; for the garnet, zircon, monazite, rutile, corumdum, titanium and other rare minerals found in them; as an ore of iron; for the manufacturing of chrome and titanium steel and other alloys or compounds; after roasting and grinding, for use as an iron-oxide paint pigment; for making heavy concrete masses such as balance weights on bascule bridges; briquetted with some form of binder into artificial cast-iron weights, such as window weights, and for other purposes.

Typical analyses of black sand from Californian sources show an average content as follows:

Magnetite	500–1100 lbs. per ton
Chromite	10– 125 lbs. per ton
Ilmenite	200– 600 lbs. per ton
Garnet	1– 80 lbs. per ton
Quartz	200–1000 lbs. per ton
Zircon	15– 25 lbs. per ton
Unclassified	100– 200 lbs. per ton

together with variable amounts of native gold and platinum.

If each of these mineral constituents could be cleanly separated at sufficiently low cost from all the others and sold independently, mining of the beach deposits might develop into a meritorious enterprise. But for all practical purposes at the present time, the value of these deposits is measured almost exclusively by their precious metal content, and this paper is concerned only with the recovery of such values.

It may be safely said that the natural concentrations of black sand in beach deposits are very low grade—much lower grade than is usually admitted by those who would exploit them.

On the other hand black sand concentrates derived from hydraulic mining operations, dredging and other forms of placer mining by the aid of special equipment, may have a value up to several thousand dollars per ton. These two classes of material should not be confused when discussing black sand.

Very few attempts have been made to systematically prospect and sample the beach deposits, either those on the present beach or the old beach deposits now lying above and one to five miles inland from the present shore line. Such samples as have been taken by government investigators and others indicate that these deposits as a whole generally contain only a few cents per ton in gold, with many samples showing no values whatever.

Experience has shown that in many cases error has been made because the true gold content of a particular sample or deposit was not known. Fire assays of representative samples by competent assayers give accurate results and should be considered final in determining the gold content. The concentrating action of the waves and ocean currents is erratic and the deposits vary in both extent and content within narrow limits. The maximum value that may be expected in quantity will not exceed 40 to 60 cents per ton. A few individuals have been able to make a living by working exceptionally high-grade spots by hand methods and a few operators have reported success working on a somewhat larger scale on material which ran 25 cents per yard. All attempts, however, to work these sands in California on a large scale have invariably ended in failure. The impression has been given out that these failures have occurred because the gold and platinum is supposed to exist in some peculiar form and that it can not be recovered by any known means. This idea is not borne out by facts. It has been shown that the gold is entirely amenable to cyanidation and to chorination. The flotation process has recently been applied successfully to the recovery of free gold in ores, and there does not appear to be any reason why the fine free gold in black sand can not be recovered with equal success by this process. The tendency of very fine free gold to float on water is well known, but so far as the writer is aware, oil flotation has not been tried in practice on auriferous black sand. A recovery comparable to that of other metallurgical processes can also be made by gravity concentration and straight amalgamation or modified forms of amalgamation, and by special machines.

The gold and platinum when present, are usually found in very fine flakes and scales and much of the gold in the old beach deposits is 'rusty' or tarnished. This makes it somewhat difficult to save in the sluice box or to amalgamate.

To aid in the recovery of fine gold in the sluice box it is customary to line the bottom with various materials. Among those used are cocoa matting, Brussels carpet, blanket, burlap, canvas, corduroy, cowhide with the hair on, sponge rubber or other similar materials. These are held down by cleats, expanded metal or wire-netting so that they can be readily removed and the gold, platinum and black sand washed out in a tub or pan for further cleaning. A number of the processes and machines that have been discussed will also make a good recovery of the values even when of microscopic size. The D. M. Wood Laboratories of Tacoma, Washington, reporting upon a sample of concentrate from one machine states:

"This material was examined microscopically; using various magnifications; from 250 to 1200 diameters. We found numerous small particles of gold and platinum in this concentrate, all too small to be seen by the naked eye, in fact the majority were too small to be seen under 250 diameters."

Satisfactory amalgamation of the 'rusty' gold can usually be accomplished by grinding the material to scour and brighten it so it will be taken up on contact with mercury. Such gold will also readily amalgamate in the presence of a solution of cyanide. Potassium or sodium cyanide solution attacks or dissolves gold and for this reason its use must be well understood or loss may occur instead of gain. Cyanide is a deadly poison even in weak solutions and it must be handled with care by an inexperienced person or its use avoided. A copper-bottomed miner's pan is best for amalgamating. A coating of mercury can usually be worked into the bottom of such pans if they are perfectly clean. A perfect coating can be obtained, also, by dissolving some water-soluable mercury salt, such as mercuric chloride in a small amount of water and pouring the solution in the pan. The mercury will then deposit on the copper. Another way is to dissolve a little quicksilver in a small amount of nitric acid. After the acid has taken up all that it will, dilute by adding considerable water (the idea being to have a very weak acid solution). Pour this in the pan and in a minute or two the copper should be coated with quicksilver. Pour off the solution. Additional quicksilver may now be added and it will take hold of the copper.

Separation of the platinum from the black sand is more readily made if the concentrate after amalgamation of the gold is screened and the different screen sizes treated as separate lots. The material should be dried and then by blowing and careful use of a magnet, a very clean platinum concentrate can be obtained. Patience and careful hand work is required.

Though perhaps too complicated for the individual, the methods described by Logan,[1] used by some of the dredging companies in cleaning up and treating their black sand concentrates, are given, as certain features may be adapted to small-scale operations.

The long tom is in universal use on dredgers to clean up. Sometimes a portion of the platinum is directly recovered in the long tom with the main part of the amalgam, but most of it is in the residual black sand concentrate, which also contains amalgam, rusty gold, scrap iron, and lead. This concentrate is run down to small volume usually in the long tom. The base metals are separated and saved. They contain some amalgamated gold which is recovered by running the metal into a bar and shipping to buyers, or sending in the accumulated base metal periodically for smelting. The platinum is recovered by panning the final long tom concentrate several times. Its separation from the small amount of gold is easy because it will not amalgamate without special treatment, but the panning is slow and must be carefully done. In many cases the black sand receives no further treatment, but is stored so that it is available for the application of any improved methods of recovering the values remaining in it. This outlines roughly the practice of many dredging companies, but each of the larger companies has its special methods for treatment of the

[1] Logan, C. A., Platinum and Allied Metals in California, State Mining Bureau, Bulletin No. 85.

black sand after the recovery of the main batch of hard amalgam, and these processes will be described.

Methods Used in Feather River District

At Oroville, the Natomas Consolidated gold man collects the black sand concentrate and amalgam in a box on each dredger and runs it through a long tom till it is reduced to one-half a small water bucket full. The long tom used is one foot wide, twelve feet long and rests on the gold tables so that it has a grade of one inch to a foot. The upper four feet of the long tom are covered with small iron riffles in solid sections one foot long, the cross riffles being an inch apart and sloping back. Below these, the bottom of the box is lined with cocoa matting under expanded metal. From this long tom the concentrate is taken to the clean-up room. The bulk of the amalgam is separated easily and is retorted. The black sand containing platinum and a little amalgam and rusty gold is washed several times in a miniature long tom and the bulk is reduced to about one pint. This contains the gold and platinum group metals. The surplus quicksilver is drawn off, and the concentrate is subjected to a 'boiling' motion, which is imparted by pouring it back and forth between two ordinary crockery bowls. This removes nearly all the black sand. Concentrated nitric acid is applied to remove any base metal and to brighten the rusty gold so that it will amalgamate. The platinum can be finally cleaned by magnet and blower to remove the remaining black sand. All the black sand is saved for future treatment.

Some of the clean-up men at Oroville have made use of the Kellogg black-sand machine to recover the platinum from the long-tom concentrate.

Platinum in this district, as well as in the other central California dredging fields, is uniformly fine, either as flakes or grains. It is probable that the best results are not obtained in the ordinary practice where panning and the long tom are used. The pan tubs used by Oroville Dredge, Ltd., gave up after careful final cleaning 12.2% of the annual platinum yield, which had escaped during the monthly clean-ups. How much more platinum remained after this last panning is problematical. The dredging superintendents generally are satisfied with any results which approximate the usual yield of platinum. They reason that the platinum is in such small quantity at best that more careful work is not justified.

Methods Used in the Yuba River District

Yuba Consolidated Goldfields have devoted considerable attention to the treatment of the black sand concentrate obtained on their dredgers. Their investment in plant and labor for this work is justified when it is remembered that each of their large dredgers gives three tons of sand concentrate a week and a total of 60 to 70 tons of this product is treated monthly. The sand handled is the black sand from the long toms, one of which is used on each dredger to recover as much gold and platinum as can be gotten in a rich concentrate of small bulk. The handling of this residual black sand concentrate does not differ materially from the practice described elsewhere for other properties, but the work done in the sand plant is different from the methods followed elsewhere.

The sand is ground in batches for two hours in a steel ball mill, with a very weak cyanide solution to brighten the rusty gold. The slime is then discharged into a well from which it is pumped into a small settling tank and is subjected to cyanide treatment in a minature plant which is housed in the same building. Leading from the ball mill is a string of sluices 40 feet long and one foot wide, with a grade of one inch to the foot. This offers the following impediments to the escape of precious metals: (1) Mercury trap; (2) two feet of silvered amalgamating plate; (3) three feet of iron cross-riffles such as are used in long toms; (4) five feet of cocoa matting; (5) eight feet of wooden riffles loaded with mercury; (6) balance of sluice covered with cocoa matting under expanded metal. After drawing off the slime the mill is run open and the sand discharges into this sluice. The process gives about $40 a ton in gold and platinum. The extraction of gold is said to be nearly perfect, but assays of the sand tailings from the sluices indicate 50¢ to 75¢ a ton in platinum still remaining. In spite of the good recovery, the tailing is not thrown away and the employes are constantly on the watch for any possible improvements in treating it.

Clean-ups made by the Marysville Dredging Company give much finer-sized platinum than that at Hammonton. After the recovery of the hard amalgam in the long tom on the dredger, the black sand is sacked and brought to the clean-up room. It is first run through a long tom 12 feet long which is fitted with iron riffles. Most of the amalgam is saved here. The sand is then rocked in a common rocker. It is next ground in batches of about two buckets for one-half hour in a three-foot arrastre. A little sulphuric acid is used to brighten the rusty gold, most of which is caught in the arrastre. The sand is finally washed through a Colorado amalgamator, which is said to get the remaining values. The concentrate from the long tom, rocker and arrastre is panned three times to get out the platinum.

Method Used in Natoma District

There is a high percentage of black and rusty gold here in some of the old terrace gravels remote from the present stream. The operating company states that most of the platinum saved is caught in the base trap of the long tom which is used on the dredger to recover hard amalgam and base metals. It is stated that the Neill jigs do not save any platinum, although successful in gold saving. The final recovery of platinum from the sand is largely in the Senn pan-motion batea. A small Hardinge mill is used to grind the sand. From this mill it passes onto an amalgamated plate two feet wide and ten feet long and thence to the Senn machine. This is operated at 160 r. p. m. The concentrate given is 10% to 30% black sand. The gold is practically all amalgamated on the batea and the platinum is caught in the bowl at the center. This machine was modified according to the ideas of E. E. Strouse, the company's gold man, and the bowl is larger and deeper than on the stock machine. In finally separating the platinum, the batea concentrate is screened. It is found to be much easier to get the platinum from sand of its own screen size, than from sand of all sizes. Some sand stops on a 40-mesh screen; some of the platinum and sand grains are fine enough to pass 100 mesh. The material entering the Hardinge mill carries about $75 a ton in values, and the

tailing from the Senn batea is said to assay $1 gold and $1 platinum. If these figures are correct, the process saves 97% of the precious metals.

La Grange Method

The Huelsdonk submerged table concentrator has been used here.

USE OF SODIUM AMALGAM

Sodium amalgam has been much touted as a 'cure-all' for the trouble encountered in amalgamating 'rusty' and tarnished gold, and more particularly for its property of amalgamating platinum. However, there are serious draw-backs to its general use.

Through the action of grease or certain oxides, sulphates, sulphides and chlorides of base metals usually found to some extent in black sand concentrates, the quicksilver used in amalgamating may become 'sickened' or 'floured.' Sodium amalgam has a powerful reducing action which will reduce the base metals from their compounds and they will then enter the quicksilver and amalgamate with it. Platinum as well as these base metals will also amalgamate with sodium amalgam. Under close technical control where the exact proportion of sodium to mercury can be controlled, it has some possible advantages in keeping the quicksilver in good condition and 'active.' In the presence of water, however, sodium hydroxide (soluble) is formed and the beneficial effects are soon destroyed. If used the resulting amalgam is base, often containing gold, platium, iron, copper, lead and other metals. The U. S. Mint will not purchase such amalgam, so that the miner now has another refining process on his hands, that of separation of the gold from the platinum and other metals, or he must ship the amalgam to a platinum refiner. Furthermore both metallic sodium used in preparing sodium amalgam and the amalgam itself must be kept away from air, usually under naphtha or kerosene, making them troublesome to handle.

Sodium amalgam is prepared by heating mercury in a dish in the open air. Small fragments of sodium about the size of a grain of wheat are cut from a stick of sodium and dropped in the hot mercury. As each piece strikes the surface there is flame and slight explosion. This is continued until the mercury becomes pasty, or until it will just stick to a bright iron nail. The use of sodium amalgam should be avoided by anyone except a trained metallurgist, as otherwise the operation is almost certain to end in a mess.

Trouble with grease may be remedied by giving the concentrates a wash of soda (soda ash) or lye and 'floured' quicksilver can usually be made to reunite by the addition of cyanide solution or by agitating it thoroughly with very dilute nitric acid to clean it.

Sanborn[1] gives the following method for recovering gold from small amounts of concentrates:

In the final recovery of gold from a washer, sluice-box or other gold-saving device, it often is possible to reduce the bulk of concentrates to a few pounds by careful panning. A simple method of recovering the gold from such concentrates is to place it in a large bottle to be worked on the principle of a 'clean-up' barrel. To do this, place the concentrates in a bottle—not more than one-fourth full; add water until it is about one-half full, and sufficient quicksilver—at least a tea-

[1] Sanborn, Frank, Mineral Technologist, State Division of Mines.

spoonful. The addition of a teaspoonful of lye for cleansing purposes is advisable. While seated, slowly tip and roll the corked bottle back and forth on your lap. After doing this for about fifteen or twenty minutes all the gold should be amalgamated. The mass is now emptied into a gold pan, more quicksilver is added and the material is panned until only a small amount of the concentrates cover the quicksilver. Hold the pan in a horizontal position and see that the mercury is in one mass. With a rather sudden tilting of the pan the gold-bearing quicksilver can be poured off; if any remains behind, add fresh quicksilver to it and repeat the pouring off process. Clean, active, quicksilver should not flour or form little globules, but should come off leaving little if any in the pan. The quicksilver is now poured into a wet chamois skin that has been laid over a cup in such a way as to form a pocket. The chamois is next twisted down onto the quicksilver—like wringing water from a wet cloth—in such a way that the quicksilver will pass through the chamois leaving hard amalgam. Some of the very fine particles of gold will also pass through the pores of the hide, but the amount will be small and this can later be saved by retorting. The hard gold amalgam can be heated gradually in the open to drive off the quicksilver, or it can be treated with hot dilute nitric acid; the acid will dissolve the quicksilver, but not the gold. Fumes of mercury if inhaled are dangerous, therefore any heating to drive it off should be done in the open.

Occasionally gold is found, especially placer gold, that will not readily form an amalgam with quicksilver. If a small amount of lye added to the water does not sufficiently clean such gold, a little potassium cyanide will usually be effective. A piece of cyanide equivalent in size to a small marble added to half a gallon of water may be sufficient to brighten 'rusty' gold. Cyanide of potassium is a dangerous poison and is not recommended for general use for this reason.

MARKETING OF GOLD, PLATINUM, AND BLACK SAND CONCENTRATES

Gold.

The U. S. Mint in San Francisco will purchase gold in the form of bars, lumps, grains, and dust in its native state, free from earth and rock or nearly so; also gold amalgam with the quicksilver expelled. Amalgam which has not been retorted will also be accepted, if it is over 200 fine, i.e., more than one-fifth pure gold. On account of the loss of quicksilver in refining, deductions for moisture, and the fact that the amalgam usually contains less gold than the seller anticipates, sale of unretorted amalgam is generally unsatisfactory.

If the material contains silver, the silver will be paid for at a price closely approximating the open market price, but the Mint does not pay for any platinum that may be associated with the gold. Gold is paid for at the rate of $20.67 per fine ounce, less the Mint charges for melting, separating, and refining. Payment is made in cash, in gold bars, or by check. Deposits are usually paid for within three to five days after they are received. The deposit may be made in person or sent in by express or mail. A letter of instructions separate from the package, should be sent to the Mint giving the approximate weight of shipment sent, name and address of sender, name of county, mining

district, or mine, where the gold was obtained and manner in which payment is to be made. Material containing 800-thousandths or more of base metals will not be received.

The rules and regulations governing the U. S. Mints state that a deposit must be of $100 value before it can be received. This would require in native gold from six to eight ounces, troy weight. However, on June 2, 1931, the Director of the Mint authorized the Superintendent at San Francisco to accept deposits of gold in quantities of two ounces or over, as an aid to the small-scale placer miner. This order applies only to mined gold and not to jewelry scrap or other fabricated metal. The permission is not permanent and may be revoked at any time, though it will likely hold during 1932.

Aside from the U. S. Mint, there are about seventy private licensed ore-buyers scattered throughout the State who buy gold, or accept it in trade for merchandise. These private buyers, of course, do not pay the equivalent of the Mint price, but as they will purchase smaller amounts, and the time and trouble of shipping to the Mint is avoided, it is often advantageous to dispose of it through them.

The following is a list of the licensed buyers with whom the miner may deal:

LICENSED GOLD BUYERS IN CALIFORNIA

Plumas County Bank, Quincy, Plumas County.
Alfred A. Kneebone, Bridgeport, Nevada County.
Chin Wing He, 1215 Lincoln St., Oroville, Butte County.
Bank of America, all branches.
American Smelting & Refining Co., 405 Montgomery St., San Francisco.
Anglo & London Paris National Bank, San Francisco.
Percy V. Carr, 240 Main St., Nevada City.
Wildberg Bros., 742 Market St., San Francisco.
Wells Fargo Bank & Union Trust Co., San Francisco.
Northern California National Bank, Redding, Shasta County.
Crocker First National Bank, San Francisco.
G. R. Randolph, 833 Market St., San Francisco.
Appleton Smelting & Refining Co., Coutolenc, Butte County.
Amador Metals Reduction Co., Jackson, Amador County.
Pacific Platinum Works, 814 S. Spring St., Los Angeles.
W. E. Moulton, French Corral, Nevada County.
Scott Valley Bank, Fort Jones, Siskiyou County.
Bank of America of California, all branches.
George W. Fraser, 439 Neal St., Grass Valley, Nevada County.
First National Bank of Oroville, Oroville, Butte County.
First National Bank in Yreka, Yreka, Siskiyou County.
T. Jones Co., Hornbrook, Siskiyou County.
Bank of Amador, Jackson, Amador County.
W. S. Macy, Iowa Hill, Placer County.
Trinity County Bank, Weaverville, Trinity County.
George W. Peltier, 1014 Eighth St., Sacramento.
Charles Yue, Auburn, Placer County.
Bennett Company, Forks of Salmon, Siskiyou County.
Levaggi Estate Co., Plymouth, Amador County.
Alonzo Elsbree, Sonora, Tuolumne County.
Dorothy B. Meikle, Foresthill, Placer County.
John Ghiorso, Sonora, Tuolumne County.
Henry C. Conger, Bangor, Butte County.
William I. May, Colfax, Placer County.
Evans Mercantile Store, Happy Camp, Siskiyou County.
Clara P. Frazer, Volcanoville, El Dorado County.
Antonio J. Costa, Downieville, Sierra County.
N. H. Burger & Son, Placerville, El Dorado County.
George H. Pratt, 105 E. First St., Los Angeles.

Chester Vergnes, Schilling, Shasta County.
Sewell Bros., 1025 Towne Ave., Los Angeles.
Forney & Welsh, Bagby, Mariposa County.
Giacomo Oneto, Angels Camp, Calaveras County.
United Loan & Jewelry Co., 531 K St., Sacramento.
M. F. Swerer, Jamestown, Tuolumne County.
S. B. Gracier, 212 Stockton St., San Francisco.
Stamper & Smith, 94 Fourth St., San Francisco.
J. Merriam & Son, Dobbins, Yuba County.
A. Brizard, Arcata, Humboldt County.
W. J. Morrison, Redding, Shasta County.
Henry W. Huckins, North San Juan, Nevada County.
G. M. Roos, Plymouth, Amador County.
James P. McLean, Auburn, Placer County.
Quinn Bros., Dutch Flat, Placer County.
Richard W. Nance, Pilot Hill, El Dorado County.
Nick Turchinetz, Chico, Butte County.
A. Domenghini, Mt. Ranch, Calaveras County.
John Norton, Cantil, Kern County.
Jack E. Bailey, Gold Run, Placer County.
Carl Langford, Somesbar, Siskiyou County.
Judson G. Goble, 419 Miner St., Yreka, Siskiyou County.
W. A. Kingdon, Crescent Mills, Plumas County.
Charles Riskin, 1552 Broadway, Oakland.
Arthur H. Sienknecht, Friant, Fresno County.
James L. Robinson, 332 Wall St., Stockton, San Joaquin County.

Platinum.

Pure platinum does not occur in nature. The tin-white, malleable metallic grains and flakes that are non-magnetic and insoluble in any single acid, which occur in some placer deposits and lag behind the gold in panning, are properly referred to as 'crude platinum.' The 'crude' metal is an alloy containing varying percentages of platinum, iridium, osmium, traces of palladium, rhodium, and ruthenium, usually some gold, a little iron and sometimes copper and nickel. Most of the crude platinum found in California will not carry over 65% platinum. Iridium is the most valuable of the platinum group metals. It is harder and heavier than platinum and when it forms a considerable part of the crude metal the grains are sharper and more angular than the softer purer platinum.

The returns received from the sale of crude platinum are usually disappointing to the miner and have caused much complaint, perhaps sometimes justified. It must be borne in mind, however, that the published quotations for platinum, iridium, osmium, etc., are for the separate, refined metals, and they do not apply to the crude material. This is well illustrated by the fact that although the quoted price of platinum was $40 per ounce, the average price of Colombian (South America) crude, basis 85% platinum, for the month of January, 1932, was $29.55 per ounce. Neither does the 'official' price quoted by the leading interest (agents for Russian platinum) mean that all sales are necessarily at that figure. Cash transactions between dealers are frequently made at a figure several dollars less per ounce. At present (March, 1932) the platinum group metals are quoted[1] as follows:

Iridium, per oz. $80–$90 for 98–99% sponge and powder.
Palladium, per oz. $19–$21.
Platinum, per oz. $40, official price of leading interest.

[1] Metal and mineral markets, Vol. 3, No. 11, March 17, 1932; Engineering and Mining Journal, New York.

Osmium, per oz. $65–$70.
Rhodium, per oz. $35–$50.
Ruthenium, per oz. $38–$48.

Based on these prices the actual value of the 'crude platinum,' if all the metals are paid for, would depend upon the percentage of each in the crude metal, less the cost of separating and refining them. Therefore, two different lots of 'crude platinum' of similar appearance may vary greatly in true value, although the miner may not realize why this is so.

Another factor complicating the price is that the seller must depend in nearly every case upon the buyer's own weights and analyses of the shipment, as the former seldom has means of checking them. The complete separation of the different platinum-group metals is a long and tedious chemical process and some platinum buyers do not make a separation of the osmium and iridium, simply estimating it as osmiridium, and neglecting the other elements.

There seems to be no simple or practical means for the small producer to overcome these marketing difficulties, and about the only choice that remains is for him to try various buyers until one is found whom he feels is fair in his dealings. The regular shipper will probably find the most satisfactory market among the larger platinum refiners and manufacturers of platinum wares in the east, but it may be equally satisfactory for the small and irregular producer to sell to some local buyer at a price somewhat approximating its actual value.

In general, well-established firms buying crude platinum are probably more just in their dealings with the miner than they are given credit for, it being hard for the latter not to overestimate the value of his product.

Among the buyers of platinum are the following:

Baker & Co., Inc., 54 Austin St., Newark, N. J.
J. Bishop & Co., Malvern, Pa.
American Platinum Works, N. J. R. R. Ave., at Oliver St., Newark, N. J.
Handy and Harman, 57 William St., N. Y.
Goldsmith Bros., Smelting and Refining Co., 29 East Madison St., Chicago, Ill.
Platinum Metals Corporation, 261 Fifth Ave., N. Y.
Irvington Smelting and Refining Works, Irvington, N. J.
S. S. White Dental Co., Philadelphia, Pa.
Wildberg Bros. Smelting and Refining Co., 742 Market St., San Francisco, Calif.
Western Gold and Platinum Works, 589 Bryant St., San Francisco, Calif.
S. B. Gracier & Sons, 212 Stockton St., San Francisco, Calif.
Shreve & Co., Bryant and Zoe Sts., San Francisco, Calif.
Geo. R. Randolph, 833 Market St., San Francisco, Calif.
Pacific Platinum Works, 814 S. Spring St., Los Angeles, Calif.

Black Sand.

At nearly every placer property where sluicing is employed there is an accumulation of black sand, containing a little fine gold and occasionally platinum. The rather tedious process of separating the precious metals from the worthless sand, without special equipment, has resulted in many inquiries for a market for the 'black sand.'

During the past several years a half-dozen or more individuals and companies, both local and in the east, have advised the Division of Mines that they had plants or processes for handling such material and

that they would buy it in large or small lots. However, prospective shippers who have approached these parties report that in nearly every case these parties have not been able, financially or otherwise, to fulfill their promises. Some sought aid in building their plant, others failed to reply to letters or acknowledge receipt of samples, so that on the whole little progress has been made in finding a market.

The Selby Smelter of the American Smelting and Refining Company, Selby, California, general office, 405 Montgomery St., San Francisco, probably furnishes the most definite outlet. This company purchases black sand concentrates having a gold value of $20 to $30 per ton and up, on a car-lot basis (15 tons). The sampling and assaying charge is $10 per ton and the treatment charge $10 per ton. They pay $19 per fine ounce for the gold contained, but no payment is made for any platinum metals that may be present. Obviously the black sand will have to be rich enough to more than cover the above charges, transportation, and mining costs, in order to yield a profit to the producer.

Apparently there is an opportunity for a small plant to do a legitimate business buying relatively low-grade black sand concentrates, but up to the present time this field does not seem to be filled. The widely scattered localities from which the material comes and number of small producers adds to the difficulty of placing such a project on a reliable and steady basis.

Rich black sand concentrates that have been 'cleaned' by the removal of practically all of the magnetite, chromite, and other worthless minerals may be sold to those listed as platinum buyers.

Those who wish to investigate other possible markets for their black sand concentrates are referred to the following parties, who may or may not provide an outlet but who have stated that they were buyers:

Regent Chemical Co., 317 Hamilton Ave., Brooklyn, N. Y.
F. F. Wilson, 5830 Birch Court, Oakland, Calif.
Reed Reduction Co., 507 Brannan St., San Francisco.
H. J. Barton, Yreka, Calif.
Jack M. Skeen, 2703 Raymond Ave., Los Angeles, Calif.
J. D. Landis, 5001 Bond St., Oakland, Calif.
George Hudson, 2558 35th Ave., Oakland, Calif.

Parsons Black Sand Reduction Works. W. L. Parsons, 958 Seventh Street, Oakland, California, proposes to treat black sand concentrates free of charge and to report the results of reduction and analysis of the residue sands to the shipper. All of the free values in the concentrate are to be retained by him to cover cost of operation, the shipper being advised of the exact amount that is extracted from any lot together with an assay for gold which may be locked up or alloyed with other mineralized sand grains. The minimum shipment acceptable on these terms is 100 lbs. and it must be prepaid.

The following bulletin issued by the General Metallurgical Laboratories may be of interest to producers:

"Gold and Platinum in Black Sands.

"During the past year there has been more than the usual amount of interest shown regarding Black Sands. This investigation is being made to determine if there is sufficient business to warrant going more extensively into the treatment of these concentrated sands.

"However, before going to the expense of adding additional equipment, it is important to know more definitely the amount of sands available, its source, value, etc.

"If you are a black sand producer, your cooperation is solicited, so will you please send in the following information:

1. Are you interested in having your sands treated?______________________________
2. How much concentrated sand have you on hand?________________________________
3. What is the approximate value per ton?______________________________________
4. How much can you consistently produce?_____________________________________
5. What is your nearest rail shipping point?___________________________________
6. Can trucks travel directly to your property?________________________________
7. Will you kindly aid this investigation by sending in the name and address of any producers that might be interested?______________________________________
8. Will you save your sands if investigation prove they carry sufficient values?______

"Sands will be investigated without cost to the producer, but a charge of $2 will be made provided they are accepted for treatment. Cost of treatment is 20% of recovery plus ½c per pound up to 2000 pounds—20% straight over 2000 lbs.

"You may be throwing away Black Sands carrying Platinum and Gold Values greater than the Free Gold you are now recovering, therefore, you should investigate.

"No sands will be treated carrying values less than $50 per ton.

"GENERAL METALLURGICAL LABORATORIES, 879 Turk Street, San Francisco.

"Specialists in Ore Treatments

"Charges on investigation sand must be prepaid."

MINING LAWS

Two Bulletins are available on the Mining Laws. Bulletin No. 106 'Manner of Locating and Holding Mineral Claims in California (with forms)' a pamphlet of 20 pages covering the essential points, price 25 cents, and Bulletin No. 98. The latter is an elaborate treatise covering all phases of mining rights, yet concise and plain reading. It is a work of 811 pages printed on thin paper and bound in flexible leather, price $2. This subject will not be discussed, therefore, other than to mention briefly one or two points frequently brought up.

License. In California no license of any kind is required to prospect on the public lands of the United States; locate mining claims, or mine on such land.

Citizenship. A valid location (claim) may be made without regard to the age, sex, residence, or citizenship of the locator; but a patent can not be obtained by an alien.

Number of Claims. There is no limit to the number of claims which the same locator or locators may take up providing there is a valuable discovery of mineral on each claim and the land is public land open to location.

River Claims. The bed of an unnavigable river or stream is open to location and patent when the opposite banks thereof have not passed into private ownership. A mining claim can not be located in the bed of a navigable river.

Beach Claims. The beach, termed in law 'tidelands,' and defined as "land uncovered at low tide and covered with water at ordinary high tide" belongs to the State for a distance of three miles out. It is not "mineral land of the public domain." Mining locations lying below the line of ordinary high tide are without authority of law, and, therefore, void. No title can be obtained to the beach and mining operations carried on there can be stopped at any time by the proper authorities.

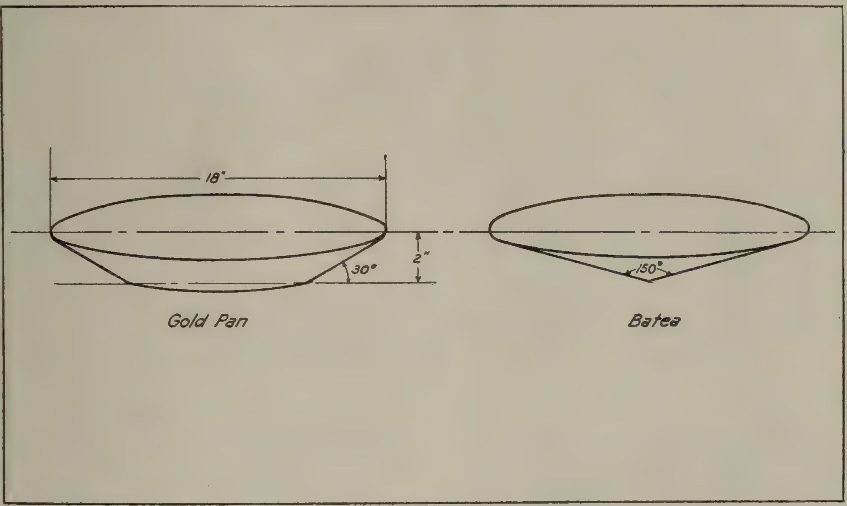
Water. The locator of a mining claim is entitled to use any water naturally flowing on or across his claim.

THE PAN, ROCKER AND SLUICE BOX

By H. H. SYMONS, Junior Mining Engineer

The equipment and operations described herein are among the simplest, and have been used in California to recover gold from placers since the days of '49. They are not only used for gold, but any heavy materials may be separated from lighter ones in this way. They are adaptable for the separation of cassiterite (stream tin), tungsten ore, cinnabar, platinum metals, gem stones, etc. Other more complicated methods of concentration are described in the preceding article by C. McK. Laizure.

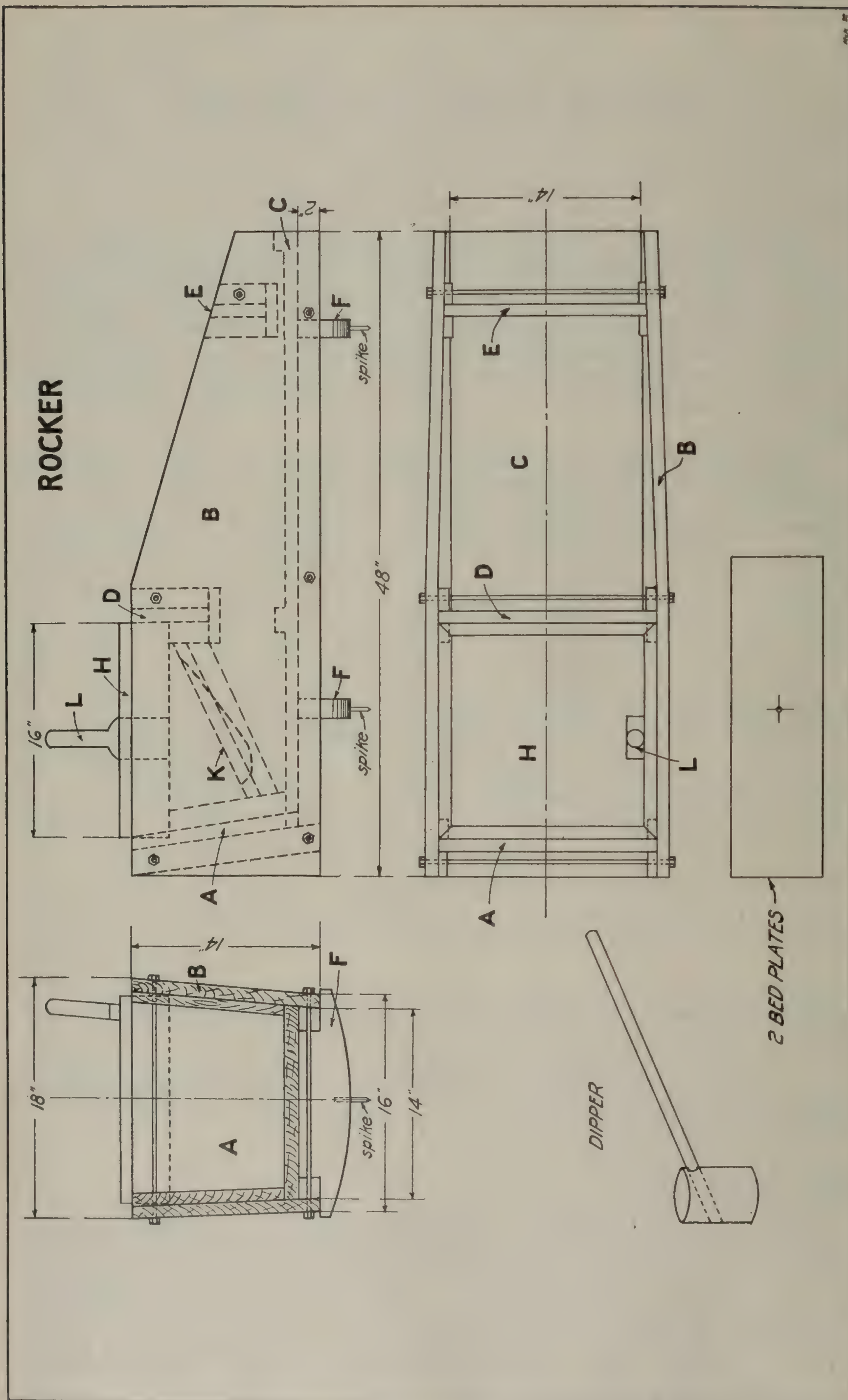
The final cleaning of concentrates obtained by these methods is also described in the preceding article.



A selected bibliography prepared by Herbert Franke which gives many valuable references will also be found in this issue of MINING IN CALIFORNIA.

Gold-Pan and Batea.

The *gold-pan* is used in prospecting for gold, in cleaning gold-bearing concentrates, and in the hand-working of very rich deposits. It is a shallow pan which varies from 15 inches to 18 inches in diameter, at the top, and from 2 inches to 2½ inches in depth, with the sides having about a 30°-slope. It weighs from 2 to 3 pounds. They are usually made of a heavy-gauge steel with the rim turned back over a heavy wire to stiffen it. Where amalgamating is to be done in the pan, they are either made of copper or have a copper bottom. When used by


ROCKER
DIPPER
2 BED PLATES
spike
16"
48"
14"
18"
2"
A
B
C
D
E
F
H
K
L

a skilled operator, it has a capacity of from half a yard to one yard in ten hours.

The object of panning is to concentrate the heavier materials by washing away the lighter. To do this most efficiently, all material should be of as even a size as possible. The pan is filled about three-quarters full of gravel to be washed, then it is submerged in water. First the large gravel is picked out by hand, then the clay is broken up, after which the operator raises the pan to the edge of the water, inclining it slightly away from him, moving it with a circular motion combined with a slight jerk, thus stirring up the mud and light sand and allowing it to float off.

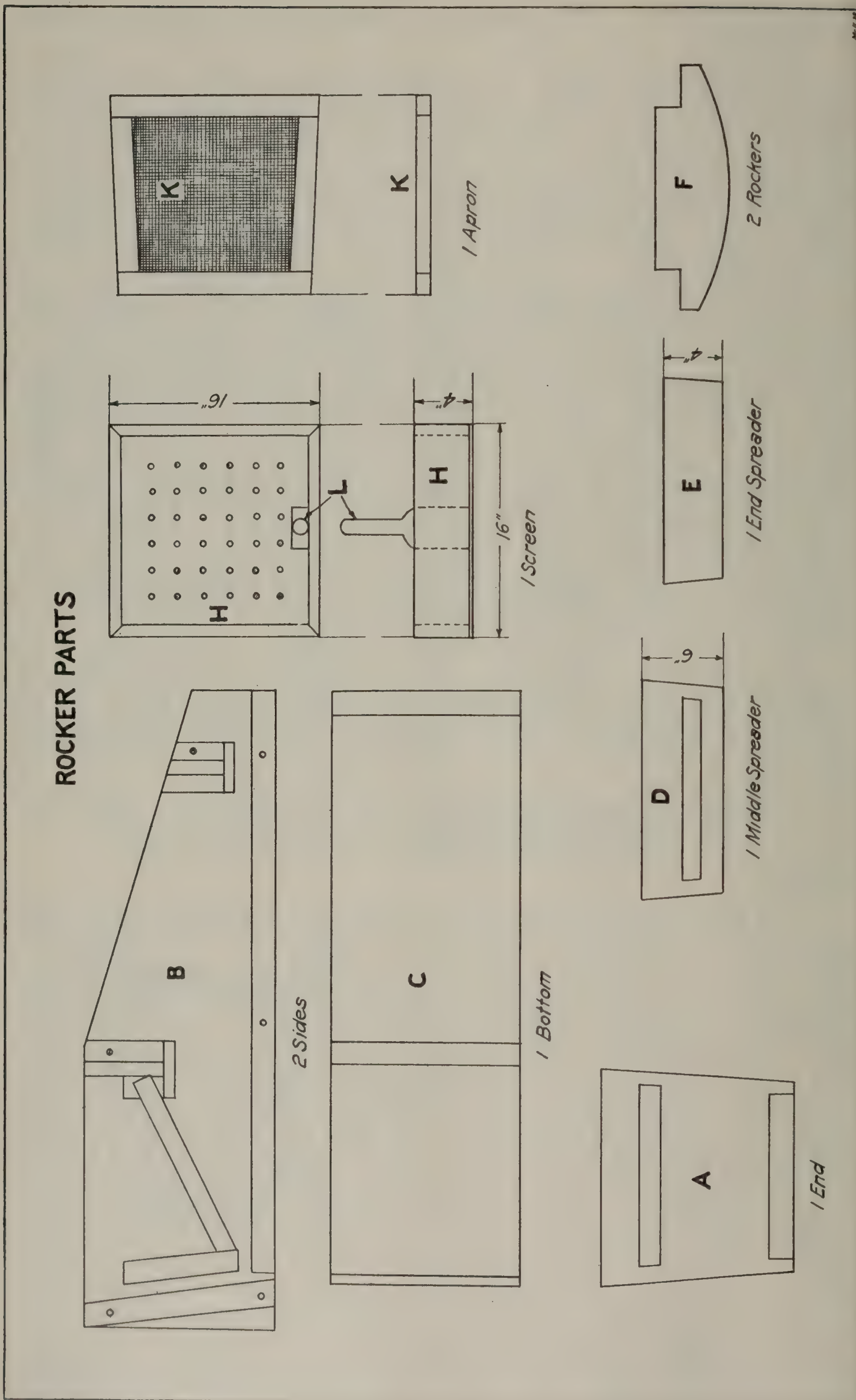
This is continued until only the heavier materials remain such as the gold, black sand and other minerals having a high specific gravity. These concentrates are saved until a large quantity accumulates, after which the gold is separated from them. It may be picked out by hand, amalgamated with quicksilver, sometimes in a copper-bottomed pan, or in some cases where the separation is extremely difficult and the quality and quantity justifies they are shipped to a smelter. Panning may be best learned by watching an old-timer or experienced operator at work, learning certain tricks in the trade from him. A clean six or eight-inch frying pan makes an excellent prospecting or clean-up pan. It is well to burn out an iron pan after having used quicksilver in it, and then polish it with a soft rock or piece of brick, otherwise it may be impossible to see small colors or flakes of gold.

The *batea* is cone-shaped and is the equivalent of the pan. It is made of wood or sheet metal. They vary from 15 to 24 inches in diameter and have an angle from 150° to 155° at the apex. It is claimed by many that wood will hold fine gold better than metal. The batea is in common use in Mexico, Central and South America, and Asia.

A shallow wooden chopping bowl may be utilized as a substitute for the batea. This would be used in the same manner as a pan.

Rocker.

The rocker is a machine to save gold from auriferous sands and gravels by concentration (sometimes in conjunction with amalgamation). They vary greatly in size, shape and general construction, depending on material available, whether the gold is coarse or fine (locality), the design considered best by the builder (experience and ease of construction). There are several gold-saving devices manually and mechanically operated described in the preceding article that are in reality forms of the rocker modified to suit conditions. This is well shown as it is easy to find rockers that vary in length from 24 to 60 inches or more, with widths varying from 12 to 24 inches, and height 6 to 24 inches. Some have a single apron, and others two aprons and screens with holes to ½-inch diameter. There will be found an even greater variety of devices to stop the values, riffles of all kinds, blanket, carpet, rubber mat, cocoa mat, canvas, cowhide, burlap, amalgamated copper plate, etc. The writer would suggest as a fairly efficient and easy construction of riffles for a rocker, to clamp ⅜-inch metal lath over a double thickness of blanket so that it can be easily removed for cleaning. Of all wet placer methods for saving gold, the rocker is one of the most economic on water for the amount of material handled. The average


ROCKER PARTS
K
K
1 Apron
16"
4"
H
L
H
16"
1 Screen
F
2 Rockers
4"
E
1 End Spreader
6"
D
1 Middle Spreader
B
2 Sides
C
1 Bottom
A
1 End

rocker when operated by two men has a capacity of about 3 to 5 yards in ten hours, using 100 to 800 gallons of water.

Construction. Rockers are built in three distinct parts, consisting of a body or sluice box, a screen and an apron. The floor of the body holds the riffles in which the gold is caught. The screen catches the coarser materials and is a place where clay can be broken up to free it of all small particles of gold. The apron is to carry all material to the head of the rocker, and being made of canvas stretched loosely over a frame, has a pocket or low place on which coarse gold and black sands can be collected.

The accompanying drawing gives a suggestion for a knocked-down rocker that can be built by any one. The material required to construct it is given in the following tabulation:

A End, one piece 1″ x 14″, 16″ long
B Sides, two pieces 1″ x 14″, 48″ long
C Bottom, one piece 1″ x 14″, 44″ long
D Middle spreader, one piece 1″ x 6″, 16″ long
E End spreader, one piece 1″ x 4″, 15″ long
F Rockers, two pieces 2″ x 5″, 17″ long
H Screen, about 16″ square outside dimensions with screen bottom. Four pieces of 1″ x 4″, 15¼″ long and one piece of screen 16″ square with ¼″ or ½″ openings or sheet metal perforated with similar sized openings.
K Apron, made of 1″ x 2″ strips covered loosely with canvas.
For cleats and apron, etc., 27 feet of 1″ x 2″ is needed. Six pieces of ⅜″ iron rod 19″ long threaded 2″ on each end and fitted with nuts and washers.
L The handle, in the drawing is placed on the screen, although some miners prefer it on the body. When on the screen, it helps in lifting the screen from the body.

If 1″ x 14″ boards can not be obtained, clear flooring tightly fitted will serve, in which case about 12 feet of 1″ x 2″ cleats in addition to that above mentioned will be needed.

A dipper made of a tomato can (2½″ can) and thirty inches of broom handle is also necessary.

Through the center of each of the rockers a spike is placed to prevent slipping when in operation.

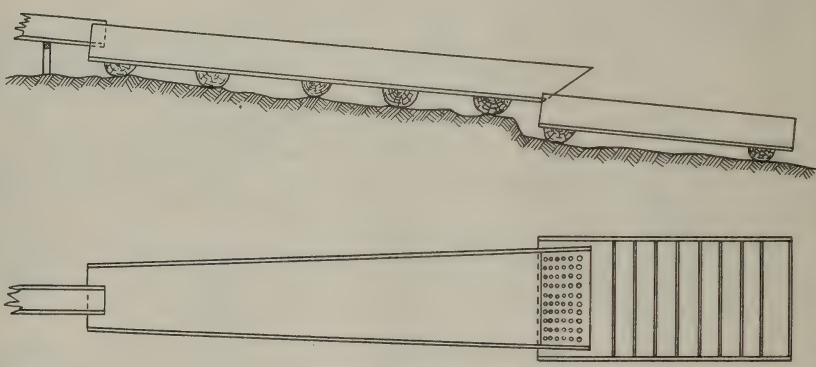
In constructing riffles, it is advisable to build them in such a way that they may be easily removed, so that clean-ups can be made more readily.

Two planks about 2″ x 8″ x 24″ long with a hole in the center to hold the spike in the rockers are also required. These are used as a bed for the rockers to work on and to adjust the slope of the bed of the rocker.

Operation. When the ground to be worked has been found, the miner picks a place near by his source of water for his rocker. The first thing to do here is to set the bed plates so that the spikes in the rocker fit in the hole in the plate and so that the floor has the proper slope. This slope is decided according to the ground to be worked. Where most of the gold is coarse and there is no clay, the head bed-plate should be 2 inches to 4 inches higher than the tail bed-plate; where most of the gold is fine or clay is present or a combination of

both, this slope is lessened sometimes to only an inch. It is hard to save very fine gold or where very muddy water is used, as the operation does not let the fine values settle out but rather floats them off.

After the rocker is placed in position, the screen box is filled with gravel, which is washed off by pouring water over this material with the dipper. The larger gravel, when clean, is either picked out with a fork or by hand and all clay is broken up into a mud. Next the machine is rocked vigorously for several minutes, continually adding water. If all material that will pass through the screen has done so, the box is dumped and this operation is repeated until it is thought necessary to clean the apron. The apron should be cleaned several times a shift, as all coarse values are caught there. These concentrates are placed in a pile for further cleaning. The riffles are cleaned whenever it is thought necessary, but not nearly as frequently as the apron, and the concentrates are saved for further cleaning. Where a blanket



LONG TOM

is used, it should be washed out carefully in a tub of water, as here a good per cent of the fine gold is found. All concentrates are cleaned further in a pan. It is important to use the right amount of water. The use of too much water will carry the material through this machine too quickly, and with it many values. And where not enough water is used, it makes a mud which will not let the fine gold settle.

Long Tom.

A long tom is an inclined trough used to concentrate auriferous earths and gravels. They have a greater capacity than a rocker, but also use more water in preparation, because the water is the carrying agent of the finer materials. They are mostly of crude construction, being built in two sections, as shown in the accompanying drawing: the sluice box, and the riffle box. Their slope is generally one inch to each foot in length, but this is varied as conditions warrant. The sluice box is usually about twelve feet long and about 15 to 24 inches

wide at the head or upper end, and 24 to 36 inches wide at the tail or lower end, with sides about 8 inches high at the tail. There is a screen or piece of perforated sheet metal to prevent the coarse material from going to the riffle box, and at the head end there is a flume or iron pipe from which the water is fed. The riffle box is usually shorter than the sluice box, and slightly wider than the latter at the tail end. It begins just below the first opening in the screen, sometimes has a more gentle slope. Here the riffles are placed to catch the values, the box often being lined with canvas and as in the rocker, it is best to build detachable riffles. The sluice box should be made of 2″ lumber to withstand the abrasion of the gravel.

The capacity of a long tom is from 4 to 6 yards in a 10-hour day, per man, two to four men working.

Operation. The ground to be worked is shoveled into the sluice box and washed by the water coming from the head end. One of the men will work the material in the trough with a fork, taking the coarser gravel out when washed clean and keeping the screen from clogging. Clean-ups are made when necessary, usually at the end of the day, but experience might show that they should be made oftener.

Sluicing.

Sluicing is a method of working auriferous gravels in a flume called a sluice box, or in a ditch, called ground sluicing.

The sluice box is a crude sloping flume or trough, having riffles on the bottom to catch the values. Their dimensions vary greatly and are governed by the amount of material to be washed through them. The slope varies from 5 to 18 inches in a twelve-foot length. The riffles also vary, sometimes there are several kinds in a single sluice, some of which are quite elaborate and require considerable work in laying.

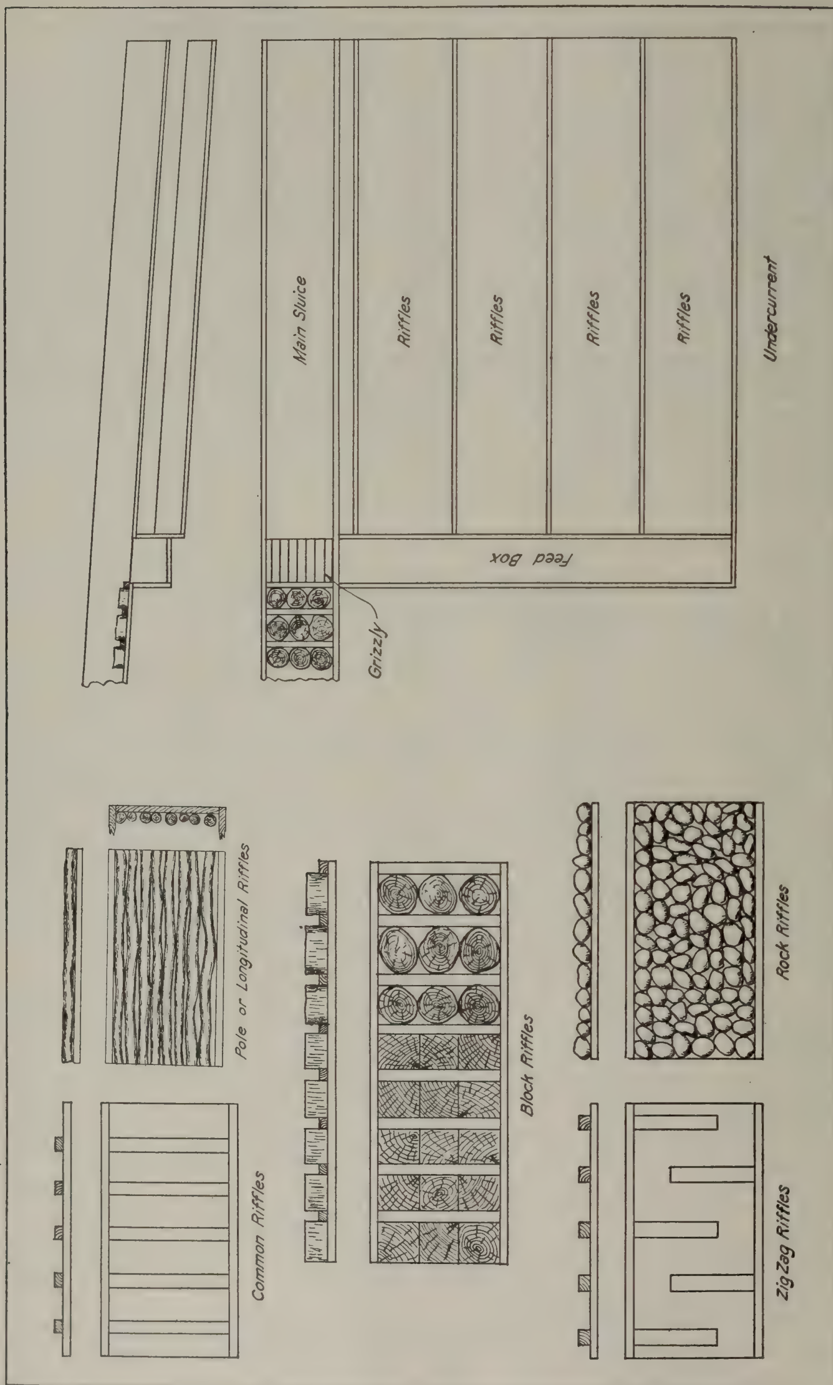
In the rocker and long tom, all the coarse materials are removed, but in the sluice all is allowed to pass through, or in some cases a grizzly is placed at the head of the sluice box to catch the very coarsest of material, but allowing much heavier gravel to enter than in the other devices previously described. This coarse material serves to grind and polish the gold, thereby cleaning it and making it easier to amalgamate, and possibly freeing some material mechanically held.

In sluicing, much of the manual labor done in the preceding methods is eliminated, as the water does all of the carrying of the material. In some cases the mining is done by hydraulicking or a stream of water is allowed to fall over a bank and in that way wash the material to the sluice.

Sluicing requires more water than the other methods previously described, the amount depending upon the material to be washed, and varying from 20 to 80 cubic feet of water to move one cubic foot of gravel. Coarse gravel requires more water than fine, but as the grade is increased the amount of water required is lessened. The capacity of the sluice box is governed by its grade and amount of water available as well as its dimensions.

In ground sluicing a ditch is dug along bed-rock and natural irregularities in the bottom furnish pockets which catch the gold.

Riffles. Riffles are obstacles placed along the bottom of a sluice which form pockets to catch values, by concentrating the heavier mate-


Main Sluice
Riffles
Riffles
Riffles
Riffles
Undercurrent
Feed Box
Grizzly
Common Riffles
Pole or Longitudinal Riffles
Block Riffles
Zig Zag Riffles
Rock Riffles

rials. There are numerous forms of riffles with innumerable modifications of which some of the best known are described in the following paragraphs:

Common riffles or slat riffles are strips of wood or iron extending across the sluice box. The abrasion is so great that replacement is required often and therefore other types of riffles are preferred in large scale operations.

Pole riffles are frequently used and are 2 to 4-inch peeled poles placed either across or lengthwise of the sluice box. This type is used with coarse material and is efficient in concentrating both coarse and fine values.

Block riffles are made by paving the floor of the sluice box with wood blocks cut across the grain, and 4 inches or more high depending on the depth and width of the sluice, in rows, nailed to slats which extend across the sluice. These may be made of either square or round blocks. This method is good for both coarse and fine materials.

Rock or stone riffles are made by paving the floor of the sluice with rock, either stream pebbles or flat stones quarried for the purpose. They are held in place by strips of wood being nailed across the bottom at intervals. This method is good for both fine and coarse material, and extra good for cemented gravel.

Zig-zag riffles are slats placed part way across the floor of the sluice box alternately from the sides. This type is good for fine material and concentrates in a similar way to panning.

An undercurrent is a wide flat sluice placed beneath the main sluice box and used for the purposes of saving the fine gold. They are usually 5 to 20 times as wide as the main sluice and from 10 to 50 feet long. They receive their feed from a grizzley or screen placed in the floor of the main sluice box from which the fine material drops into a trough which distributes the feed evenly across their whole width. Undercurrents usually have a more gentle incline than the main sluice

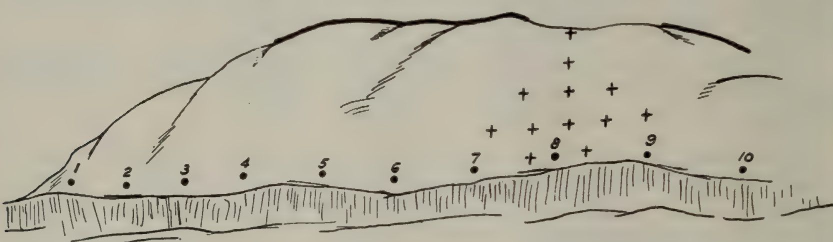
8—94259

PROSPECTING FOR VEIN DEPOSITS

By FRANK SANBORN, Mineral Technologist.

To narrate an actual instance of a gold discovery and the procedure of the prospector in uncovering the orebody may be a convenient way of describing this fascinating work. Since 1929, hundreds of people in this state have made their first attempt to search for minerals. For those who care conscientiously to prospect in a mineralized section, there is exhilaration and possible gain to be had.

During most of the western gold booms of the past, much, if not most of the locating of a district was done by inexperienced people who, in a more or less panicky way, tried to see how much ground they could claim, and located any open land within a radius of five or ten miles of the original discovery. The idea in many cases was to obtain and sell the property at a high price; the close-in claims usually



Prospecting a hillside. Beginning at dot No. 1 a sample was taken and thence every 50 or 100 ft. At point 8 the best prospect was found. Samples were then taken as represented by + until the crest of the hill was reached; in this case the vein was rich, but did not outcrop.

being the best sellers. Many such pieces of ground were purchased by wild-catters whose chief intention was to sell stock.

In the fall of 1905 when the boom was on in Goldfield, Nevada, and when that region was about two years old, Mr. J. R. Davis, a mining man, who understood prospecting, arrived in camp. The district was already located for miles around; some leasers were shipping high-grade ore, and the camp was all excitement.

Mr. Davis looked carefully over the district. He decided to prospect Sandstorm Hill, on the crest of which a large quartz vein outcropped. Cross-cut trenches had been made on this vein and many samples assayed. The outcrop was known to have a small gold content, as the assays usually showed a value ranging from a few cents to a dollar or so a ton, but as yet nothing worth while had been found.

Sandstorm is a low hill, rising about 200 feet above a dry, rocky gully or wash. Mr. Davis started at the foot of the lower end of this isolated hill just above the gulch, at a point where the over-burden had not been disturbed. With a shovel he removed the loose surface cover to a depth of a few inches, then took a full shovel of earth for a

sample and placed it in a labeled bag. He then advanced along a contour-like line parallel to the edge of the gully for a distance of forty or fifty feet where a second sample was taken, and so on until a number had been obtained. He then went to his tub of water and panned each of these carefully, watching for any traces of gold. Most of these samples showed a trace of the yellow metal as might be expected in this section; but Mr. Davis was looking for tests that would show a slightly better prospect than these. He returned to his work of sampling and continued taking more at intervals of about fifty feet, just above the edge of the dry creek. A point was finally reached where the soil showed an increase in its gold content. This was the point where careful panning was now to be done. Here, samples were taken at twenty-foot spacings, and one of these was found to be richer than any of the others. Our prospector then proceeded up the hill about twenty feet above the point where his best find so far had been made and took samples at intervals of about twenty feet in a line parallel to the first. The best gold producing hole in this line was marked; up the hill about twenty feet more shovels of earth were taken to outline the boundary of the gold flow. In this way the hill was ascended on the fan-shaped area containing gold float, the source of which was on the top of the hill, a section of the quartz vein that did not outcrop—a depression rather than an exposure. A lease was obtained on the enriched part of the claim, and in five months it yielded $240,000.

The Loftus-Davis Lease on the Sandstorm was not the only gold deposit that Mr. Davis ever found. He has to his credit four more—small ones, but all were profitable.

In Siskiyou County, the old Schroeder and Warner Mine situated above the headwaters of McAdams Creek was another of the many producers found by prospecting according to a system. Mr. Schroeder, after watching the placer operations around Deadwood, decided to attempt to find the source of most of this gold that was being recovered from the creek. Accordingly, he set out with his gold-pan on a tracing expedition up Deadwood cañon. The branching cañons leading into Deadwood were tried and the branches showing the least amount of gold were eliminated. By this system of elimination the main gold float was traced until it suddenly diminished greatly at a point near the source of McAdams Creek. This disappearance of gold was an indication; so the gold seeker went back a short distance to investigate the hillsides by 'post-holing' as this particular method of sampling is often called. Loose gold was found on the hill and subsequently traced to its source. In this case the float was traced about five miles to its origin. It is stated a month or more was spent in the search. The Schroeder and Warner Mine is reputed to have produced several hundred thousand dollars.

The writer, while at the Union Mine, near El Dorado, in El Dorado County, from 1915 to 1918, occasionally devoted a little time to prospecting the surface of these old mining claims, using a system similar to that of Mr. Davis. On one claim he had reason to believe a gold-bearing vein existed although there was no visible outcrop of quartz. After some systematic panning, colors were found, and shortly afterward the vein was uncovered. The orebody from whence the gold float

came proved to be only about fifteen or twenty feet in length and from four to six inches wide, but as it was a well-defined vein having a gouge on one wall, the owners thought enough of its possibilities to install a headframe and sink a shaft to a depth of two hundred feet where drifts were run.

A second vein on another claim of the Union group was likewise found. Like the first, however, it was a small ore shoot and was abandoned after about a hundred feet of work had been done. It is true they did not prove profitable, but there were enough indications present to warrant some work whether they had been found in 1852 or 1917. These statements are made to show what is possible in many old mining districts as well as new ones.

The writer also found a small silver-lead prospect in the Monte Cristo Range, Nevada, by tracing float to its source. In this instance, while slowly ascending, in the meanwhile observing and occasionally breaking rocks for observation, especially quartz; a honey-combed, yellowished stained quartz containing traces of a lead mineral was noticed. The superficial geographic feature of the region was a small valley encompassed by gradually rising hills. The natural assumption was that this rock to be traced originated at some higher level. If, at its source, a great tank of water had been emptied, the water flow would about cover the same ground as the float. Slowly walking up the grade in a zig-zag fashion, a second piece of this same characteristic quartz was discovered, and farther up more was picked up. Finally the float was traced to a steep hill, and in traversing the foot of this hill, much of the quartz was found in a trace of a water course. The source of the ore was found about half way up the hill and a distance of about a mile from where the first float was seen. The tracing took about half a day. The locator was surprised to find such a large amount of float coming from such a small vein.

Tales of lost mines such as the Breyfogle have been of interest to many. Likely, in most of these cases, if gold was found it was merely float from some hidden source.

Before me is a letter just received from a man in Dixieland, California. He states: ''Sample No. 6 consists of models of gold nuggets found in this district. They were found on a dead man near here twenty years ago. I saw the nuggets.''

The assumption is, I presume from further statements, that the unfortunate man did not possess the gold before he went on his fatal prospecting trip in the Mud Hills.

About two years ago a woman visitor at our office exhibited a piece of native gold worth several dollars. She stated that her home was in the southern part of the State, but while vacationing near Downieville, Sierra County, she had found the metal on a mountain side; there being no visible signs of mining work in the vicinity.

When gold is found in the hills as float, the discovery spot should be immediately marked, and then if a superficial tracing expedition does not reveal more, a systematic examination of the ground by panning should next be undertaken.

In making a preliminary examination of a section by panning, such as the hills on the side of a canyon, some prospectors take samples from little gullies, or small water courses, or pick out portions showing

yellow or red stains that are caused by oxides of iron resulting from the oxidization of some iron-bearing mineral. Sometimes it will be found that a small hillside gully or a trace of a water course will yield a color or more in a pan. If it is thought justifiable, systematic prospecting should start where the best indications of gold were found.

When a mountain side is a thousand feet or so from top to bottom, a line of samples at its base may not be sufficient. A line parallel to the base or crest could be taken every two hundred feet or so.

Frequently a quartz vein will outcrop only in spots, but the general course of the vein can be traced. In this case it is advisable to start about fifteen or twenty feet below the apparent course of the vein and sample the ground at intervals of twenty feet or so. Even when a vein outcrops, such sampling is usually advisable.

Gold-bearing quartz veins do not necessarily out-crop at the surface. Some veins are heavily penetrated with sulphides such as pyrite, and these sulphides oxidize leaving the quartz in a state that can easily be crumbled, the result being that sometimes instead of an outcrop there is a depression and no visible sign of quartz. The oxidation of iron-bearing minerals will often stain the surrounding overburden a reddish or yellowish color. Some prospectors make a special effort to pan such discolored zones.

A regulation gold pan is most suitable for panning loose earthy material. When quartz is pulverized in a mortar a handful of the material can be conveniently panned in a small frying pan free from grease. Pans should be kept clean by scouring them with sand, pumice or similar material.

Most of the large gold-bearing quartz outcrops in the United States have been discovered, but undoubtedly there exists many valuable deposits of gold and other minerals that are hidden from surface view; some of these will be discovered by methodical searching and some by accident.

USE OF THE PAN IN PROSPECTING

With a little effort anyone can soon become skilled in the practical use of a miner's pan. For the novice it would be advisable to begin with a small frying pan that contains no grease; in fact, such a pan will answer for all prospecting purposes in the absence of a regulation gold pan. For the first attempts at this method of concentrating, a couple of pounds of sandy gravel and a few flakes of gold or some other heavy mineral, such as a small amount of the sulphide of lead, called galena, or cinnabar, the red sulphide of mercury, should be mixed with the gravel. A single sample can be used over and over again.

Fill the pan about three-fourths full of the material to be tested; hold it in a horizontal position and slowly submerge it in a large basin or tub of water. With the fingers thoroughly mix the water and sample, picking out any large pebbles; this may be done while the pan is either under or out of the water. With the horizontal position as a start, shake the water-filled pan rapidly with a rotating movement, tipping it in the meanwhile slowly and slightly from the horizontal. After thus shaking the pan a few seconds, hold it in the slightly tipped position and give it several rapid, short, jerky shakes from side to side in order that the heaviest minerals may sink towards the bottom. Keeping the slightly tipped position, again slowly sink the pan in the water, rotate

and tip it a little more to float off the top material which would be the coarser pebbles. The object is to retain only the heavy mineral grains that should now be in the lowest part of the pan. This operation of submerging, rotating, shaking and tipping the pan is repeated several times; each time a little more of the sample is floated off, until a stage is reached where only about a tablesponful of the sample is left and the pan is in a greatly inclined position with the heaviest of the remaining grains in the very bottom. For the final investigation have just enough water in the pan to cover the remaining concentrates, hold it about focal distance from the eyes—elbows to the sides and the pan tipped towards you. Now, shake the greatly tipped pan with very short, quick strokes, the meanwhile slowly raising one side in an effort to have the heaviest part of the concentrates form a 'tail' in the ridge of the greatly inclined pan.

Examine the 'tail' very carefully for any traces of gold or any other heavy material. With a magnetized knife blade stir the 'tail' concentrates while they are covered with a little water. Magnetite grains and fragments of iron will be picked up; examine the concentrates again after using the magnetized knife blade. If gold is thought to be present, watch it carefully in the meanwhile slowly turning and tipping the pan. Gold retains its color in any position while pyrite or other mineral grains that may resemble gold in one light reflection may change color when the angle of reflection is altered.

For a beginner, known minerals should first be used in panning. Gold-bearing rock of a milling grade can generally be obtained in any gold mining district; also, pan the common sulphide of iron called pyrite. Next to gold, the sulphide of lead called galena is probably the most important mineral to pan and learn to identify. Galena is often associated with silver and gold. There are gold ores that will not show a color (one visible grain of gold) in a panning test, but such ores often contain a small amount of galena or the lead carbonate called cerussite which is usually almost white in color. In these cases the gold is so finely divided and intimately mixed with the lead minerals and pyrite that it can not be seen even with a powerful hand lens. Such an ore was found in the Surcease Mine in Butte County and at other properties in this State. Whenever lead minerals are found, the ore should be assayed for gold and silver. In the case of tellurides, which are very scarce in California, there is practically always enough free gold present to give colors in panning, but if not, the tellurides will concentrate and will be investigated by a careful observer.

We usually associate the operation of panning with gold; but silver, lead, tungsten, quicksilver, and platinum metals can also be found by this simple method of concentration.

SELECTED BIBLIOGRAPHY ON PLACER MINING

By Herbert A. Franke, Junior Mining Engineer.

The following bibliography has been selected from government publications, textbooks, and papers dealing with California's gold placer resources and from other subject matter which would help in the recovery of these resources. Many references are not listed, as time did not permit an exhaustive search.

The publications are generally given with full title, following the names of the authors, which are arranged in alphabetical order. The general arrangement of the bibliography is:

I. Placer Resources
II. Placer Mining Methods
III. Miscellaneous

Symbols:

* Available for consultation at principal libraries.

† Obtainable from the Superintendent of Documents, Washington, D. C.

‡ Obtainable from Publications Section, U. S. Bureau of Mines, Washington, D. C.

§ Obtainable from Publisher.

° Obtainable from the State Division of Mines, Ferry Bldg., San Francisco, and its branch offices at Bankers Bldg., Los Angeles; State Office Bldg., Sacramento; Chamber of Commerce, Redding. Also from State Division of Oil and Gas at Bank of Italy Bldg., Bakersfield; San Marcos Bldg., Santa Barbara; Taft, Coalinga and Santa Paula.

M. & S. P.—Mining & Scientific Press.

E. & M. J.—Engineering & Mining Journal.

I

Alling, M. N.—Ancient River-Bed Deposits in California. E. & M. J.—Press (sic.), Vol. 1, Sept. 20, 1922, pp. 134–140; Oct., 1922, pp. 161–166.*

Brooks, E. F.—Platinum in California, M. & S. P., Vol. 114, Jan. 27, 1917, p. 116.*

Browne, J. Ross—Hydraulic Mining Ditches of California. Mineral Resources West of the Rocky Mountains, Section XIX, 1868, pp. 179–206.*

Browne, Ross E.—Ancient River Beds of the Forest Hill Divide. 10th Annual Report of the State Mineralogist, 1890, pp. 435–465.*

Crossman, J. H.—Auriferous Gravels of San Gabriel Range, San Bernardino Co. 9th Annual Report of the State Mineralogist, 1888–1889, pp. 236–237.*

Day, D. T.—Notes on the Occurrence of Platinum in North America. Trans. Am. Inst. Min. Eng., Vol. 30, 1900, p. 702.*

Day, D. T., Wilson, C. E., and Clevenger, G. H.—Electric Smelting of Magnetite from Black Sands. Mineral Resources of the U. S., 1905, U. S. Geol. Survey, 1906, pp. 1247–1257. 15¢†

Diller, J. S.—Geology of the Lassen Peak District. 8th Annual Report of the U. S. Geological Survey, 1886–1887, Part I, pp. 401–432.*

The Auriferous Gravels of the Trinity River Basin, Calif. Bulletin 470, U. S. Geological Survey, 1910.*

Auriferous Gravels in the Weaverville Quadrangle, Calif. Bulletin 540, U. S. Geological Survey, 1912.*

Geology of the Taylorsville Region, California. Bulletin 353, U. S. Geological Survey, 1908. 30c.†

Mineral Resources of the Indian Valley Region, Calif. Bulletin 260, U. S. Geological Survey, pp. 45–49, 1904.*

Dunn, R. L.—Drift Mining in California. 8th Annual Report of the State Mineralogist, 1888, pp. 736–770.*

Auriferous Conglomerate in California (Siskiyou Co.). 12th Annual Report of the State Mineralogist, 1893–1894, pp. 459–471.*

Edman, J. A.—Auriferous Black Sands of California. E. & M. J., Vol. 83, June 1, 1907, pp. 1047–1048.*

Notes on the Gold Bearing Black Sands of California. M. & S. P., Vol. 69, 1894, pp. 294, 356, 372.*

Auriferous Black Sands of California. Bulletin 45, California State Division of Mines, 1907.*

Endlich, F. M.—Mining in the Mojave Desert in California (Goler Dry Placers). E. & M. J., Vol. 62, Aug. 29, 1896, pp. 197–198.*

Fairbanks, H. W.—Red Rock, Goler and Summit Mining Districts, in Kern County. 12th Annual Report of the State Mineralogist, 1893–1894, pp. 456–458.*

Goodyear, W. A.—The Auriferous Gravels of California. M. & S. P., Vol. 39, Sept. 20, 1879, pp. 182–183.*

Gruetter, F. W.—Platinum on the Pacific Coast. M. & S. P., Vol. 113, July 1, 1916, pp. 20–21.*

Hall, C. L.—The Gravel Fields of Northern California. M. & S. P., Vol. 74, Feb. 6, 1897, p. 113.*

Haley, Chas. S.—Gold Placers of California. Bulletin 92, California State Division of Mines, 1923.*

Dry Placers of Southern California (Abstract). E. & M. J.-Press, Vol. 1, Dec. 1922, pp. 235–236.*

Hammond, John Hays—Auriferous Gravels of California; Geology of Their Occurrence and Methods of Their Exploitation. 9th Annual Report of the State Mineralogist, 1888–1889, pp. 105–138.*

Hornor, R. R.—Notes on the Black Sand Deposits of Southern Oregon and Northern California. Technical Paper 196, U. S. Bureau of Mines, 1918.*

Hubbard, J. D.—Drift Mining in California. E. & M. J., Vol. 104, Nov. 17, 1917, pp. 863–866.*

Hutchins, J. P.—The Nomenclature of Modern Placer Mining; The Numerous Classifications of Placers are Discussed in General and in Particular; Origin of Placers and Methods of Exploitation. E. & M. J., Vol. 84, Aug. 17, 1907, pp. 293–296.*

Jamison, C. E.—Santa Clara River Placers. (Los Angeles and Ventura Counties). M. & S. P., Vol. 100, Mar. 5, 1910, pp. 360–361.*

Janin, Chas.—Topography and Geology of Dredging Areas. M. & S. P., Vol. 117, Dec. 7, 1918, pp. 763–764.*

Kemp, J. F.—Platinum and Associated Metals. Bull. 193, U. S. Geol. Survey, 1902, pp. 51–53.*

Kimble, Geo. W.—The Kimble Drift Mine, El Dorado County, Calif. M. & S. P., Vol. 85, July 12, 1902, p. 23.*

Ancient River Channels of California. M. & S. P., Vol. 94, June 8, 1907, pp. 726–727.*

Lindgren, Waldemar—The Tertiary Gravels of the Sierra Nevada of California. Professional Paper 73, U. S. Geological Survey, 1911.*

Two Neocene Rivers of California. Bulletin of the Geological Society of America, Vol. 4, June 19, 1893, pp. 277–298.*

Logan, C. A.—Platinum and Allied Metals in California. Bulletin 85, California State Division of Mines, 1919.*

MacDonald, D. F.—The Weaverville-Trinity Center Gold Gravels, Trinity County, Calif. Bulletin 430, U. S. Geological Survey, 1910, pp. 48–58.*

Perret, L. A.—Gold in Black Sand (Berdan Pan). M. & S. P., Vol. 123, 1921, pp. 423–424.*

Smyth, H. L.—Origin and Classification of Placers. E. & M. J., Vol. 79, June 1, 1905, pp. 22 and 29.*

Sperry, A. W.—Investigation of Feather River Black Sands. M. & S. P., Vol. 105, Nov. 16, 1912, p. 624.*

State Mineralogist's Reports I to XXVIII, 1880–1932; but especially Reports XXI to XXVIII, 1925–1932, issued quarterly at 25 cents a copy, which describe mines and mineral resources as to counties. (See Publications of Division of Mines, p. I.)

Storms, W. H.—Gold Formations of California. M. & S. P., Vol. 76, Jan. 29, 1898, pp. 110–111.*

Ancient Channel System of Calaveras County. 12th Annual Report of the State Mineralogist, 1893–1894, pp. 482–492.*

Taylor, Geo. F.—The Brandy City Hydraulic Mine, Sierra County. E. & M. J., Vol. 89, June 4, 1910, pp. 1152–1153.*

Turner, W. H.—Cretaceous Auriferous Conglomerate of the Cottonwood Mining District, Siskiyou County, Calif. E. & M. J., Vol. 76, Oct. 31, 1903, pp. 653–654.*

Whitney, J. D.—Auriferous Gravels of the Sierra Nevada of California, 1880. Contributions to American Geology, Vol. 1, from the Memoirs of the Museum of Comparative Zoology of Harvard.*

Wiel, S. C.—The Ancient Channel of Gibsonville, Calif. M. & S. P., Vol. 91, July 29, 1905, p. 73.*

Yale, C. G.—Dry Placers of California. Mineral Resources of the U. S., Part I, U. S. Geological Survey, 1912, pp. 262–263.*

Young, Geo. J.—Drift Mining at Vallecito, Calaveras County, Calif. E. & M. J., Vol. 128, Sept. 7, 1929, pp. 394–397.*

Anonymous—Auriferous Gravels of the Sierra Nevada described in Folios Nos. 3, 5, 17, 18, 29, 31, 37, 39, 41, 43, 51 and 66 of the Geological Atlas of the U. S., of the United States Geological Survey.*

Hydraulic Mining on the American and Bear Rivers. M. & S. P., beginning July 24, 1875, and ending Feb. 19, 1876.*

Hydraulic Mining at Gold Run—The Blue Lead Ancient River Channel. M. & S. P., Vol. 30, Mar. 13, 1875, pp. 168–169.*

Hydraulic Mining in Humboldt County, Calif. E. & M. J., Vol. 79, Feb. 23, 1905, p. 362.*

Hydraulicking in Trinity County, Calif. (La Grange Mine). M. & S. P., Vol. 101, July 30, 1910, p. 143.*

Hydraulicking at La Grange Mine, Trinity County. E. & M. J., Vol. 95, May 17, 1913, pp. 1005–1007.*

Iron and Steel from Pacific Coast Black Sands. Western Machinery World, Nov., 1921.*

Making Pig Iron and Steel from Pacific Coast Black Sands. Iron Trade Review, Sept. 29, 1921.*

Mineral Resources West of the Rocky Mountains, 1867 to 1876. By J. Ross Browne, James W. Taylor, and Rossiter W. Raymond.*

Old Channel Placers. M. & S. P., Vol. 82, Apr. 13, 1901, pp. 175–176.*

Platinum. M. & S. P., Vol. 78, Jan. 28, 1899, p. 88.*

Platinum Metals of Plumas County, Calif. M. & S. P., Vol. 77, Oct. 22, 1898, p. 401.

Trinity River Gravels, California. E. & M. J., Vol. 92, Sept. 9, 1911, pp. 495–497.*

Useful Minerals in the Black Sands of the Pacific Slope. Mineral Resources of the U. S., 1905, U. S. Geological Survey, 1906, pp. 1175–1228. 15¢.†

II

Allen, A. W.—Fundamentals of Amalgamation. E. & M. J., Vol. 116, Aug. 18, 1923, pp. 275–280.*

The Berdan Pan for Amalgamation. E. & M. J., Vol. 106, Dec. 21, 1918, pp. 1075–1076. Also see p. 780, E. & M. J., Vol. 125, May 12, 1928.*

Aubrey, L. E.—Utilization of Black Sands. E. & M. J., Vol. 83, June 15, 1907, p. 1158.*

Birkenbine, John, Hydraulic Pumping Plant on the Snake River, Idaho. Trans. Am. Inst. Min. Eng., Vol. 30, 1900, p. 518.*

Bowie, A. J., Jr.—A Practical Treatise on Hydraulic Mining in California, 1885. Published by D. Van Nostrand, New York.*

Brazenall, W.—Collecting Black Sand. E. & M. J., Vol. 85, May 11, 1907, p. 918.

Campbell, D. F.—La Grange Hydraulic Mine. M. & S. P., Vol. 97, Oct. 10, 1908, pp. 491–493.*

Chapman, C. M.—Edison Dry Process for the Separation of Gold from Gravel. E. & M. J., Vol. 75, May 9, 1903, p. 713.*

Cox, S. H.—Prospecting for Minerals. 8th Edition, 1921. Published by Chas. Griffin & Co., Ltd., London.

Edman, J. A.—Black Sand. M. & S. P., Vol. 93, Sept. 29, 1906, p. 380.

Davis, J. A., and Gross, J.—Recovery of Gold from Black Sand by Classified Concentration. U. S. Bureau of Mines, Report of Investigations No. 2160, 1920.*

Recovery of Gold from Black Sand. M. & S. P., Vol. 122, 1921, p. 504.*
Recovery of Gold from Magnetic Black Sand. U. S. Bureau of Mines, Report of Investigations No. 2158, 1920.*
Doolittle, J. E.—Gold Dredging in California. Bulletin 36, California State Division of Mines, 1905.*
Egleston, T.—The Treatment of Fine Gold in the Sands of Snake River, Idaho. Transactions of the American Institute of Mining Engineers, Vol. 18, 1889–1890, pp. 597–609.*
Egleston, T.—The Metallurgy of Silver, Gold, and Mercury in the U. S. 2 Vols. Published by J. Wiley & Sons, N. Y., 1890.
Elffner, A. E.—Beach Mining With a Surf Washer. M. & S. P., Vol. 36, June 6, 1903, p. 364.*
Ellis, H. I.—Prospecting Methods at Fairbanks. E. & M. J., Vol. 99, Nov. 19, 1915, pp. 805–810.*
Gardner, W. H.—Drilling for Placer Gold. Published by Keystone Driller Co., Beaver Falls, Pa.
Gilbert, G. K.—Hydraulic Mining Debris in the Sierra Nevada. M. & S. P., Vol. 116, March 16, 1918, pp. 371–374.*
Hydraulic Mining Debris in the Sierra Nevada. Professional Paper 105, U. S. Geological Survey, 1917. 50 cents.†
Gross, J.—Comparison of Methods of Gold Recovery from Black Sand. U. S. Bureau of Mines, Report of Investigations No. 2192, 1920.*
Recovery of Gold from Black Sand Tailings. U. S. Bureau of Mines, Report of Investigations No. 2170, 1920.*
Haley, Chas.—Elevating Ten Cent Gravel at a Profit. M. & S. P., Vol. 104, 1912, pp. 530–532.*
Hartley, Carney—The Recovery of Fine Gold and Black Sand. E. & M. J., Vol. 97, 1914, pp. 843–844.*
Hazard, F. H.—The Saving of Fine Placer Gold. E. & M. J., Vol. 92, Aug. 26, 1911, pp. 394–396.*
Hershey, O. H.—A Remarkable Deposit of Black Sand—Isthmus of Panama. M. & S. P., Vol. 77, Oct. 22, 1898, p. 401.*
Hill, J. M.—Notes on the Fine Gold of Snake River, Idaho. Bulletin 620-L, U. S. Geological Survey, 1916.*
Horton, F. W.—Utilization of Black Sand. E. & M. J., Vol. 83, May 4, 1907, p. 867*
International Library of Technology—Placer Mining, Surface Arrangements, Ore Mining, Assaying, etc. Published by International Textbook Co., Scranton, Pa.
Jackson, C. F., and Knabel, J. B.—Small-Scale Placer-Mining Methods. I. C. 6611, U. S. Bureau of Mines, 1932.‡
Janin, Chas.—Placer Mining Methods and Operating Costs. Chapter of Bulletin 121, U. S. Bureau of Mines, 1916.*
Present Day Problems in California Gold Dredging. American Institute of Mining and Metallurgical Engineers, Vol. 42, 1912, pp. 855–874.*
Gold Dredging in the U. S. Bulletin 127, U. S. Bureau of Mines, 1918. 50 cents.†
Kirkpatrick, T. S. G.—The Hydraulic Gold Miner's Manual. 2d Edition. 1897. Published by E. and F. N. Spon, London and New York.
Knox, H. B. and Haley, C. S.—The Mining of Alluvial Deposits. The Mining Journal (London), Vol. 12, No. 2, p. 89; Vol. 12, No. 3, p. 153; Vol. 12, No. 4, p. 211, 1915.*
Lakes, Arthur—Prospecting for Gold and Silver in North America. 2d Edition, 1896. Published by the Colliery Engineer Co., Scranton, Pa.
Laizure, C. McK.—Some Special Methods and Machines for the Recovery of Gold and Platinum in Placer Deposits. January, 1929, Chapter of Twenty-fifth Report of the State Mineralogist, California State Division of Mines; 25¢ a copy.°
Lang, Herbert—Black Sand: M. & S. P., Vol. 93. Dec. 29, 1906, p. 776.*
Leaver, E. S.—Recovery of Fine Gold by Amalgamation. E. & M. J., Vol. 127, Apr. 13, 1929, pp. 601–602.*
Longridge, C. C.—Hydraulic Mining, 1910. The Mining Journal, London.*
Mather, H. A.—The Problem of the Dry Placers. E. & M. J., Vol. 76, Aug. 29, 1903, pp. 314–315.*
Maxwell, L. A.—Black Sand: M. & S. P., Vol. 93, Nov. 10, 1906, p. 564.*

Nichol, J. M.—Black Sand: M. & S. P., Vol. 94, Jan. 19, 1907, p. 82.*
The Metallurgy of Alluvial Mining. M. & S. P., Vol. 110, 1915, pp. 837–840.*
Parkhym, H. A.—Black Sand Investigation. E. & M. J., Vol. 82, Dec. 29, 1906, p. 127.*
Paul, A. B.—The Black Sand Gold Question. M. & S. P., Vol. 69, Oct. 13, 1894, pp. 230–231.*
Peele, Robert—Mining Engineers' Handbook. 2d Edition, 1927 (two volumes). Published by John Wiley & Sons, Inc.§
Powell, F.—Black Sand Problem. E. & M. J., Vol. 84, Aug. 10, 1907, pp. 251–252.*
Purington, C. W.—Methods and Costs of Gravel and Placer Mining in Alaska. Bulletin 263, U. S. Geological Survey, 1905.*
Radford, W. H.—Notes on Hydraulic Mining of Low-Grade Gravel. Vol. 31, Transactions of the American Institute of Mining Engineers, 1907, p. 918.*
Richards, R. H., and Locke, C. E.—Textbook of Ore Dressing, 2d Edition, 1925. Published by McGraw-Hill Book Co., Inc., New York.§
Richards, R. H.—Utilization of Black Sand. E. and M. J., Vol. 84, June 29, 1907, p. 1251.*
Sperry, E. A.—Recovery of Flour Gold from River Sand. E. & M. J., Vol. 128, Oct. 12, 1929, pp. 581–582.*
Staley, W. W.—Elementary Methods of Placer Mining. Pamphlet No. 35, Idaho Bureau of Mines and Geology, 1931.*
Storms, W. H.—How to Make a Rocker. E. & M. J., June 24, 1911, p. 1243.*
Taggart, A. F.—Handbook of Ore Dressing, 1927. Published by John Wiley & Sons, Inc., New York.§
Townsend, A. R.—Black Sands. E. & M. J., Vol. 85, Feb. 8, 1908, pp. 307–308.*
Tyrrell, F. G.—An experience with Black Sands on the Beach at Nome. M. & S. P., Vol. 113, Dec. 30, 1916, p. 937.*
Von Bernewitz, M. W.—Handbook for Prospectors, 2d Edition, 1931. Published by McGraw-Hill Book Co., Inc., New York.§
Weatherbe, D'Arcy—A Hydraulic Mine in California. (Spring Valley Mine, Cherokee, Butte Co.) M. & S. P., Vol. 93, Sept. 8, 1906, pp. 296–298.*
Theller, J. H.—Hydraulicking on the Klamath River. M. & S. P., Vol. 108, Mar. 28, 1914, pp. 523–526.*
Wilson, E. B.—Hydraulic and Placer Mining, 3d Edition, 1918. Published by John Wiley & Sons, Inc., New York.§
Wimmler, N. L.—Placer Mining Methods and Costs in Alaska. Bulletin 259, U. S. Bureau of Mines, pp. 215–220, 1927. 55¢.†
Winston, W. B., and Janin, Chas.—Gold Dredging in California. Bulletin 57, California State Division of Mines, 1910.*
Wood, H. E.—Separating Metallics from Pacific Coast Sands. E. & M. J., Vol. 109, 1920, pp. 398–399. (Refers chiefly to concentration of chromite and zircon.)*
Utilization of Black Sands. E. & M. J., Vol. 84, July 13, 1907, p. 81.*
Young, J. W.—Concentration of Black Sands. E. & M. J., Vol. 80, Dec. 30, 1905, p. 1204.*
Young, Geo. J.—Elements of Mining, 2d Edition, 1923. Published by McGraw-Hill Book Co., Inc., New York.§
Anonymous—Amalgamating Gold Ores and Sands with Aid of Centrifugal Force. E. & M. J, Vol. 132, Sept. 14, 1931.
Auriferous Black Sands of California. E. & M. J., Vol. 83, June 1, 1907, pp. 1047–1048.*
Black Sands. M. & S. P., Vol. 114, Feb. 17, 1917, p. 225. Vol. 93, Sept. 1, 1906, p. 242. Vol. 94, Jan. 19, 1907, p. 68.*
Black Sand Investigation. E. & M. J., Vol. 82, Oct. 27, 1906, pp. 793–794.*
Black Sand Mining. M. & S. P., Vol. 69, Oct. 27, 1894, p. 263.*
Black Sands on Pacific Coast. M. & S. P., Vol. 113, Dec. 2, 1916, p. 811.*
Dredging. E. & M. J., March 13, 1897; Nov. 20, 1897; Dec. 11, 1897; Dec. 25, 1897; Aug. 4, 1900; Aug. 11, 1900; Aug. 18, 1900; June 29, 1901; July 6, 1901; Nov. 7, 1903; March 31, 1904; July 7, 1904; Dec. 8, 1904; July 15, 1905; July 22, 1905; Apr. 14, 1906; Apr. 21, 1906; May 30, 1908; Apr. 24, 1909; Oct. 15, 1910; July 8, 1911; Sept. 30, 1911; from Feb. 17, 1912, to May 31, 1913; Aug. 19, 1916; June 23, 1917; Jan. 22, 1916; Jan. 5, 1918; Feb. 7, 1914; Mar. 28, 1914; Apr. 4, 1914; Aug. 22, 1914; March, 1923; May, 1922,* Vol. 1, pp. 6–9. M. & S. P., Jan. 5, 1901; Jan. 12, 1901; Nov. 2 to Dec. 14, 1901; Apr. 16, 1904; Apr. 15, 1905; Apr. 22, 1905; Apr. 29, 1905; Aug. 19 to

Sept. 9, 1905; May 4, 1907; Aug. 15, 1908; Apr. 15, 1911; Oct. 7, 1911; Oct. 14, 1911; Feb. 24, 1912; Mar. 2, 1912; Mar. 9, 1912; Mar. 8, 1913; Nov. 8, 1913; Nov. 22, 1913; Feb. 22, 1919; Apr. 5, 1919.*

Dry Blowers in Australian Gold Placers. E. & M. J., Vol. 74, Oct. 11, 1902, pp. 482–484.*

Gold-Saving Riffles on a Dredge. E. & M. J., Vol. 108, Dec. 6, 1919, p. 865.*

Investigation of Black Sands from Placer Mines. Bull. 285, U. S. Geol. Survey, 1905, pp. 150–164.*

Mining of Beach Sands. M. & S. P., Vol. 74, May 15, 1897, p. 405.*

Notes on Hydraulic Mining of Low-Grade Gravel. Trans. Am. Inst. Min. Eng., Vol. 31, 1901, p. 617.*

Notes on the Gold Bearing Black Sands of California. M. & S. P., Vol. 69, Nov. 10, 1894, p. 294.*

Placer Mining Methods. Reports of Investigations 2315, U. S. Bureau of Mines, 1922.‡

Spring Valley Hydraulic Gold Mine. M. & S. P., Vol. 43, Dec. 31, 1881, pp. 441, 452.*

Utilization of Black Sands. E. & M. J., Vol. 83, May 18, 1907, p. 966. Vol. 82, Dec. 29, 1906, p. 1224. Vol. 83, Apr. 13, 1907, p. 724.

III

Anderson, J. W.—Prospector's Handbook. Published by D. Van Nostrand, New York.§

Eakle, A. S.—Minerals of California. Bulletin 91, California State Division of Mines, 1923. $1 a copy.°

Hill, J. M.—The Mining Districts of Western United States. Bulletin 507, U. S. Geological Survey, 1912.*

Lock, A. G.—Gold: Its Occurrence and Extraction. 1882. Published by E. and F. N. Spon, London and New York.

Platts, J. B.—Pocket-Hunting Applied to Prospecting. M. & S. P., Vol. 113, Aug. 26, 1916, p. 306. (Quartz Mining.)*

Ricketts, A. H.—Manner of Locating and Holding Mineral Claims in California. Bulletin 106, California State Division of Mines, 1931. 25¢ a copy.°

American Mining Law. Bulletin 98, California State Division of Mines, 811 pp., flexible leather, 1931. $2 a copy.°

Rogers, A. F.—Introduction to the Study of Minerals and Rocks. 2d Edition, 1921. Published by McGraw-Hill Book Co., Inc., New York.§

Rose, T. K.—The Metallurgy of Gold. 2d Edition, 1896. Published by Chas. Griffin & Co., Ltd., London.

Shedd, Solon—Bibliography of the Geology and Mineral Resources of California to the end of 1930. Bulletin 104, California State Division of Mines, 1932. In press.°

Anonymous—Gold Placers of Parts of Seward Peninsula, Alaska. Bulletin 328, U. S. Geological Survey, 1908. 70¢.†

Platinum—Hints for Prospectors. Pamphlet of U. S. Geological Survey. No. 34549. Free.§

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes of personnel during the past three months, to be noted.

New Publications.

'Mining in California' (quarterly), October, 1931, being Chapter 4 of the State Mineralogist's Report XXVII, price 25 cents. Contains: "Mines and Mineral Resources of Alpine County"; "Progress Report of Geologic Branch"; "Geology of San Jacinto Quadrangle South of San Gorgonio Pass"; "Notes on Mining Activity in Inyo and Mono Counties in July, 1931"; also "Index" for Report XXVII (1931).

Commercial Mineral Notes, Nos. 106, 107, 108, February, March, April, 1932, respectively. These 'notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet, monthly. It is mailed free to those on the mailing list for 'Mining in California.' As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded in recent months to two pages.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

California's counties produced for some years past more than 50 different mineral substances, the total value of which for 1931 was estimated at $220,299,000 (see January, 1932, issue of 'Mining in California').

At present (April, 1932) reports for most of the producers are in hand. Data for several substances are now complete and have been compiled, being presented herein. Information at hand indicates that there was no production during 1931 of the following, which have, at one time or another in the past, been on our commercial list: arsenic, antimony, asbestos, bismuth, fluorspar, graphite, lithia, molybdenum, serpentine, shale oil, strontium, tin, titanium and zinc. There was a single operator in each of the following: bromine, cyanite, iodine, iron ore, manganese ore, mica, mineral paint, potash, sulphur, and tungsten.

The first recorded commercial production of iodine as a mineral substance in California was made during the year 1931. From 1929 on, there has been a small experimental output coming from the saline waters of the deep oil wells in the Long Beach field. There was also a small amount extracted from kelp during 1917 to 1921 by an experimental station of the U. S. Department of Agriculture at Summerland, Santa Barbara County.

BARYTES

During 1931 there was a commercial production of crude barytes in California amounting to a total of 27,682 short tons valued at $156,047 f.o.b. rail shipping point. This was an increase in both quantity and value over the 1930 output, which was 19,783 tons worth $133,107. The 1931 yield came from a single property each in Inyo, Mariposa, Santa Barbara, Shasta, and Tulare counties. This material was consumed in the manufacture of lithopone, as heavy-gravity oil-well drilling mud and barium chemicals. The mining of barytes has been showing a steady increase with 1929 showing the largest annual production.

More than half of the total tonnage of barytes utilized in the United States is taken in the manufacture of lithopone, which is a chemically-prepared white pigment containing approximately 70% barium sulphate and 30% zinc sulphide. This is one of the principal constituents of 'flat' wall paints. Other important uses for barytes, after washing and grinding, are as an inert pigment and filler in paint, paper, linoleums, oilcloth and rubber manufacture, and in the preparation of a number of chemicals including barium binoxide, carbonate, chloride, nitrate, and the sulphate precipitated, or 'blanc fixe.'

The Tariff Act of 1930 placed a duty on foreign imported barytes ore, crude or unmanufactured, of $4 per ton; ground or otherwise manufactured, of $7.50 per ton.

Present quotations for barytes (93% $BaSO_4$) vary from $6 to $7 (Calif. $7) per ton, crude, f.o.b. rail-shipping point. Most barite has to be washed and acid treated to remove iron stains or other impurities before being suitable for paint use.

Known occurrences of this mineral in California are located in Inyo, Los Angeles, Mariposa, Monterey, Nevada, San Bernardino, Shasta and Santa Barbara counties. The deposits at El Portal, in Mariposa County, have given the largest commercial production to date. in part witherite (barium carbonate, $BaCO_3$). Witherite has also been found in Shasta County, but no shipments have yet been made from the deposit.

BORATES

During 1931 there was produced in California a total of 203,755 tons of borate materials, compared with 215,986 tons for the year 1930. The material shipped during the year included the new sodium borates, kernite (rasorite), kramerite and some colemanite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County.

As the crude ore is not sold as such, but is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, and because of the fact that the material varied widely in boric acid content, we have recalculated the tonnage to a basis of 40 per cent, A. B. A. This is approximately the average A. B. A. content of the colemanite material after calcining, and also of the crystallized borax obtained from evaporation of the lake brines.

Recalculated as above, the 1931 production totaled 206,405 short tons valued at $5,753,037. This was a slight decrease in tonnage, but an increase in value over the 1930 output, which was 209,869 tons worth $3,686,817.

Colemanite is a calcium borate, and the material mined is shipped to seaboard chemical plants for refining. The latest development in the borax industry is the finding in quantity and opening up of a group of new borate minerals which have now supplanted colemanite in much the same way that colemanite deposits displaced the borax industry in the desert playas or dry lakes, some forty years ago. These new minerals are 'kernite' (or 'rasorite'), a sodium borate with a smaller water-of-crystallization content than the 'borax' of commerce, so that when recrystallized to borax, the resulting product has an increased weight over the original material, and kramerite, a hydrous sodium-calcium borate. These deposits are being mined by the Pacific Coast Borax Company, Suckow Borax Mines, Inc., and Western Borax Company, in southeastern Kern County.

Refined 'borax' (sodium tetraborate) is used in making the enameled coating for cast-iron and steelware employed in plumbing fixtures, chemical equipment, and kitchen utensils. It is also a constituent of borosilicate glasses which are utilized in making lamp chimneys, baking dishes, and laboratory glassware. Other important uses of borax are in the manufacture of laundry and kitchen soaps, in starch, paper sizing, tanning, welding, and in the preparation of boric acid,

which is employed as an antiseptic and in preserving meats. Among the newer uses for borax is its employment in the preserving of citrus fruits by washing them in a solution of borax, which closes the pores of the skin. The application of this process is stated to be important in California and Florida. Another is as a preservative of wood, in addition to which borax, being noninflammable, renders it fireproof.

The total amount of borates exported from the United States[1] during the year 1931 was 86,938 short tons valued at $3,358,609, as compared with 82,931 tons worth $3,057,794 in 1930.

CEMENT

During 1931 there was a production of 7,693,712 barrels of cement valued at $11,510,655 f.o.b. plant, being a decrease in both quantity and value from the preceding year. The 1930 output was 9,831,938 barrels worth $14,575,731, or an average value of $1.48 per barrel. The average value per barrel in 1931 was $1.49.

The 1931 production came from ten plants operating in nine counties and employing a total of 1496 men. Two plants were in operation in San Bernardino County and a single plant in each of the following counties: Calaveras, Contra Costa, Kern, Los Angeles, Merced, Riverside, San Mateo and Santa Barbara.

There has been an interesting parallelism in the output of the Portland cement and the crushed rock, sand and gravel industries in California. The use of concrete has been a most important development in structural work during the last 20 or 30 years, and has made possible the building of such great monolithic structures as our irrigation and hydro-electric power dams, as well as highway pavements and skyscraper office buildings.

CHROMITE

Chromic-iron ore or chromite, recalculated to the basis of 45% Cr_2O_3, amounting to 441 short tons valued at $6,737 f.o.b. rail shipping point was sold in California during 1931. This was an increase over the 1930 figures, which were 84 tons and $1,905. This material came from properties in El Dorado, Fresno, Placer, and Tuolumne counties, in addition there was a property each in Placer, San Luis Obispo and Shasta counties which mined chromite, but did not ship any during the year. The grade of the material shipped varied from 17% (which was concentrated) to 55% Cr_2O_3.

The political and commercial control of chromite now rests largely with England, through the ownership and sales contracts exercised by the Chrome Company (Ltd.), of London. That company controls both the Rhodesian and the New Caledonian output.

Occurrence.

Until 1916, when some shipments were made from Oregon and smaller amounts from Maryland, Wyoming and Washington, practically our only domestic production of chromite for many years came from California. From 1830 to 1870 the deposits in Maryland supplied the world's consumption.

[1] Monthly Summary of Foreign Commerce of the United States, Department of Commerce, Dec., 1931, Part 1.

Chromite is widely distributed in California, the principal production, thus far, having come from El Dorado, San Luis Obispo, Del Norte, Shasta, Siskiyou, Placer, Fresno, and Tuolumne counties. In 1918 a total of 29 counties contributed to the state's output. There are two main belts in California yielding this mineral, one along the Coast Ranges from San Luis Obispo County to the Oregon line, including the Klamath Mountains at the north end, and the other in the Sierra Nevada from Tulare County to Plumas County. Chromite occurs as lenses in basic igneous rocks such as peridotite and pyroxenite, and in serpentines which have been derived by alteration of such basic rocks. For the most part, so far as developments have yet shown, the lenses have proved to be small, relatively few of them yielding over 100 tons apiece. A notable exception to this was the deposit on Little Castle Creek, near Dunsmuir, from which upwards of 15,000 tons were shipped before it was exhausted. Deposits worked in Del Norte County during 1918 promise well for a large tonnage. On the whole the orebodies in the northwestern corner of the State appear to average larger in size than the chromite lenses in other parts of California.

Concentration became an accomplished fact in several localities, thus utilizing some of the disseminated and lower-grade orebodies which have been found. In fact, an important part of the 1918–1920 production of California came from that source.

Imports.

Imports of foreign chromite[1] duty free, mainly from Rhodesia New Caledonia and India, totaled 212,528 long tons valued at $3,314,776 for the year 1931, compared with 330,531 tons worth $3,513,123 in 1930.

Uses.

The major consumption of chromite ore is for use as a refractory lining in smelting furnaces for steel and copper. A smaller portion is used in the preparation of ferrochrome for chome-steel alloys, and of chromium chemicals, the latest development of which is chrome plating as used in the automobile industry, on ships, and in oil refineries to protect metal surfaces from wear and erosion. It is stated that during the last five years, the sales of chromite brick and chromite cement have increased 500%, because of their replacing magnesite which is more expensive.

GYPSUM

During the year 1931 there were shipments of gypsum in California amounting to 88,354 short tons valued at $199,198, coming from two properties in Riverside County and a single property in each Fresno, Imperial and Kern counties. This was a decrease in both quantity and value from the 1930 output, which was 116,865 tons worth $243,507.

Uses.

The most important use of gypsum from the quantity standpoint is in the calcined form where it is utilized in the manufacture of various

[1] Monthly Summary of Foreign Commerce of U. S. Bureau of Foreign and Domestic Commerce, Part 1, Dec., 1931.

hard-wall plasters and plaster board. As plaster of paris, it plays a very important part in surgical work. Approximately 2%, by weight, raw gypsum is added in the manufacture of Portland cement just before the final grinding. In this application, the gypsum acts as a retarder to the set of the cement. The use of gypsum tile for non-bearing fireproof partitions, stairway and elevator enclosures, and the protection of steel columns, girders and beams, has increased greatly.

Keene's cement is a gypsum product, calcined to complete dehydration, and an accelerator added such as alum, potassium sulphate, borax, aluminum sulphate.

Land plaster may be applied to the soil by drilling, or scattered in the hill, or it may be sowed broadcast, in quantities ranging from 200 to 500 pounds to the acre.

MAGNESITE

The production of magnesite during the year 1931 amounted to a total of 21,576 tons of crude ore valued at $182,283. Only a small part of this was sold crude, however, as it was practically all shipped in the calcined form. The reports at hand show that a total of 8781 short tons shipped calcined valued at $298,722 rail shipping point. Of the above 21% was dead-burned and periclase for refractory purposes, the balance going to the plastic trade. This material came from Santa Clara, Stanislaus and Tulare counties with a single producer in each. From 2 to 2½ tons of crude material are mined to make one ton of calcined.

The 1931 output showed a decrease in both quantity and value from the 1930 figures, which were 38,681 short tons worth $388,472. The average value of the crude magnesite reported for 1931 was $8.45 per ton compared with $10.04 in 1930; $10.32 in 1929, $11.00 in 1928 and $12.50 in 1927.

Occurrence.

Magnesite is a natural carbonate of magnesium, and when pure contains 52.4% CO_2 (carbon dioxide), and 47.6% MgO (magnesia). It has a hardness of 3.5 to 4.5, and specific gravity of 3 to 3.12. It is both harder and heavier than calcite (calcium carbonate), and also contains a higher percentage of CO_2 as calcite has but 44%.

Most of the Californian magnesite is comparatively pure, and is ordinarily a beautiful, white, fine-grained rock with a conchoidal fracture resembling a break in porcelain. The Grecian magnesite is largely of this character; but the Austrian varieties usually contain iron, so that they become brown after calcining. The Washington magnesite resembles dolomite and some crystalline limestones in physical appearance. Its color varies through light to dark gray, and pink.

In California the known deposits are mostly in the metamorphic rocks of the Coast Ranges and the Sierra Nevada, being associated with serpentine areas. The notable exceptions are the sedimentary deposits at Bissell in Kern County and at Afton in San Bernardino County. Several thousand tons have been shipped from the Bissell deposit; and small shipments have been made from the Afton property.

The Washington deposits are associated with extensive strata of dolomite limestone. The magnesite there appears to contain more iron

than most of the California mineral, which makes it desirable for the steel operators. However, recent experience has proved that several California localities have sufficient iron in their magnesite to be serviceable in the steel furnaces.

Uses.

The principal uses include: Refractory linings for basis open-hearth steel furnaces, copper reverberatories and converters, bullion and other metallurgical furnaces; in the manufacture of paper from wood pulp; and in structural work, for exterior stucco, for flooring, wainscoting, tiling, sanitary kitchen and hospital finishing, etc. In connection with building work it has proved particularly efficient as a flooring for steel railroad coaches, on account of having greater elasticity and resilience than 'Portland' cement. For refractory purposes, the magnesite is 'dead-burned'—*i. e.*, all or practically all of the CO_2 is expelled from it. For cement purposes it is left 'caustic'—*i. e.*, from 2% to 10% of CO_2 is retained. When dry caustic magnesite is mixed with a solution of magnesium chloride ($MgCl_2$) in proper proportions, a very strong cement is produced, known as oxychloride or Sorel cement. It is applied in a plastic form, which sets in a few hours as a tough, seamless surface. It has also a very strong bonding power, and will hold firmly to wood, metal, or concrete as a base. It may be finished with a very smooth, even surface, which will take a good wax or oil polish. As ordinarily mixed there is added a certain proportion of wood flour, cork, asbestos, or other filler, thereby adding to the elastic properties of the finished product. Its surface is described as 'warm' and 'quiet' as a result of the elastic and nonconducting character of the composite material. The cement is frequently colored by the addition of some mineral pigment to the materials before mixing as cement.

For refractory purposes the calcined magnesite is largely made up into bricks similar to fire-brick for furnace linings. It is also used unconsolidated, as 'grain' magnesite. For such, an iron content is desirable, as it allows a slight sintering in forming the brick. Dead-burned, pure magnesia can not be sintered except at very high temperatures; and it has little or no plasticity, so that it is hard to handle. Its plasticity is said to be improved by using with it some partly calcined or caustic magnesite. Heavy pressure will bind the material sufficiently to allow it to be sintered.

A coating of crushed magnesite is laid on hearths used for heating steel stock for rolling, to prevent the scale formed from attacking the fire-brick of the hearth.

Pure magnesite which is fused to a hard flint-like mass called 'artificial periclase,' will not shrink with additional heat and is used as a refractory for high temperatures.

Before the World War, practically all of the domestic output of caustic magnesite was used in the manufacture of pulp and paper. For this purpose calcined dolomite is now used. The use of dolomite instead of magnesite by the paper manufacturers began during the war when the price of magnesite was very high. Dolomite was found to be a good substitute for magnesite in the bisulphite process of paper making and so its use has continued.

PUMICE AND VOLCANIC ASH

The production of pumice and volcanic ash in California during the year 1931 amounted to 11,461 short tons valued at $107,130, coming from two properties each in Fresno, Inyo and Siskiyou counties and a single property each in Imperial, Kern, Mono, San Bernardino and San Luis Obispo counties. The 1931 output showed a decrease from that of 1930, which was 12,947 tons worth $128,847.

The material from Imperial, Inyo, Mono, San Bernardino, and Siskiyou counties was pumice and scoria, the vesicular block variety, and was used in acoustic plaster, light-weight aggregate for concrete, and for abrasive purposes. The product from Fresno, Kern and San Luis Obispo was the volcanic ash, or tuff variety, and was employed in making soap, cleanser compounds, and a large tonnage is being utilized as a concrete filler in cement displacement. The Kern county ash is going into the preparation of one of the popular and nationally advertised brands of cleanser compounds.

PYRITES

A total production of 25,402 short tons of pyrite, valued at $131,174 was reported shipped in California during 1931, coming from properties in Alameda and Shasta counties. This was a decrease in both quantity and value from the 1930 output, which was 39,958 tons worth $194,228.

This material was mostly used in the manufacture of sulphuric acid for explosives and fertilizer. Some iron sulphate has been produced previously and was utilized directly in the preparation of an agricultural fertilizer and insecticide. The sulphur content ranged up to 50.8 per cent S.

This does not include the large quantities of pyrite, chalcopyrite, and other sulphides which are otherwise treated for their valuable metal contents. Some sulphuric acid is annually made as a by-product in the course of roasting certain tonnages of Mother Lode auriferous concentrates while under treatment for their precious metal values.

SODA

The production of sodium salts in California in 1930 included: Soda ash, trona, caustic soda and bicarbonate from plants at Owens Lake, Inyo County, and trona ('sesqui-carbonate,' a double salt of Na_2CO_3 and $NaHCO_3$) from Searles Lake, San Bernardino County. There were no shipments of salt cake (sulphate) from the Carrizo Plains, San Luis Obispo County, in 1930. The output for the year amounted to 78,701 short tons valued at $1,217,811, compared with the 1930 figures which were 90,122 tons and $1,627,344.

The dense ash and bicarbonate were used mainly in the manufacture of soap, glass, paper, oil refining, sugar refining, and chemicals; and the trona for metallurgical purposes.

Sodium compounds to some extent replace potassium compounds, in glass and soap making, in photography, in match making, in tanning, sugar refining, and in the manufacture of cyanide for extracting gold and silver from their ores.

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America; and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

Frank Sanborn, Mineral Technologist

The work required of the laboratory is somewhat unique, made so by the thousands of requests for information of various kinds. On an average, we receive about thirty-five rock samples a day, mostly from prospectors and miners who are in hopes of finding a mineral of commercial importance. Each sample is investigated as thoroughly as is deemed necessary to supply the requested information. Several regular assays for gold, silver or platinum metals are made each day, and also a few qualitative analyses; others are identified by inspection, simple tests, or with the microscope. When a mineral is found that may have commercial possibilities, the sender is informed of its chief uses, and a list of possible buyers is furnished, or information given that may assist in finding a market for the product. Also, a record of the mineral is kept on file so that anyone looking for a particular mineral may have the names of those who have submitted such, even though it may have been ten years ago. Approximate returns are given on gold and silver ores; but when we believe the ore is from a new discovery, and perhaps the sender may not be able to pay a commercial chemist for an assay, we usually volunteer to do a limited amount of his assaying to help him get started.

One of the requirements of a prospective member of the staff is several years actual mining experience; as a result, we have in the department men who have qualified and held jobs as miners, timbermen, tool-sharpeners, cyanide, flotation and stampmill operators, in fact, all branches of gold and silver mining have been covered. Considerable information of a special nature is often sought, especially from small operators or those who are attempting work that is new to them. The troubles of the mill-men and some others are usually referred to the laboratory, consequently, numerous letters sent out are of a nature suggesting such corrections as feeding less quicksilver to the mortar; try working your steel while it is at a much lower heat, or the like. Also, people come to the laboratory for instructions in the

use of the miner's pan, or for making simple field tests that are necessary to determine if a certain element is present in a rock. The mineral technologist has a busy day, and time-limit prevents more detailed reports being issued, such as he would often like to give.

During the past ten or twelve years more or less excitement was started in certain sections of the State by either romancers or imposters. The 'tin excitement' of Southern Oregon and Siskiyou County, schemes for the recovery of platinum from the waters of Mono Lake, and the 'mysterious white metal' were some of these. In these and other cases the Division of Mines was usually the first to receive samples and be consulted by people who were innocently interested. As a result of our reports to them, the wrath of some promoters was bestowed upon us, but, nevertheless, we are ever striving to serve the public, whatever their mining problems may be.

LIBRARY

Herbert A. Franke, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some five thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, Mining in California contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Government, National

U. S. Geological Survey:

Bulletins:

- 824 —Mineral Resources of Alaska, 1929. By P. S. Smith and others.
- 827 —A Geologic Reconnaissance of the Dennison Fork District, Alaska. By J. B. Mertie, Jr.
- 831-A—The Jackson Gas Field, Hinds and Rankin Counties, Mississippi. By W. H. Monroe.
- 834 —Bibliography of North American Geology, 1929 and 1930. By J. M. Nickles.

Professional Papers:

- 170-B—The Upper Cretaceous Ammonite Gems Barroisiceres in the United States. By J. B. Rieside, Jr.
- 170-D—Pliocene Fossils from Limestone in Southern Florida. By W. C. Mansfield.

Water Supply Papers:

- 637 —Contributions to the Hydrology of the U. S., 1930.
- 662 —Part 2—South Atlantic and Eastern Gulf of Mexico Basins.
- 675 —Surface Water Supply of Hawaii, July 1, 1927, to June 30, 1928.

688 —Part 8—Western Gulf of Mexico Basins.
690 —Part 10—The Great Basin.
704 —Part 9—Colorado River Basin.

U. S. Bureau of Mines:

Bulletins:

346 —Physical Testing of Explosives. By C. E. Monroe and J. C. Tiffany.

Technical Papers:

506 —Microscopic Study of Elkhorn Coal Bed at Jenkins, Tetcher Co., Ky.
508 —Coke-Oven Accidents in the U. S., 1930.
509 —Production of Explosives in the U. S., 1930.
510 —Results of some Magnetic Measurements on Dikes, with Experiments upon Geophysical Differentiation of Nickel-Ore Deposits in the Sudbury District, Ontario, Canada. By F. W. Lee.

Mineral Resources of the United States:

Asbestos in 1930.
Asphalt and Related Bitumens in 1930.
Barite and Barium Products in 1930.
Bauxite and Aluminum in 1930.
Cement in 1930.
Chromite in 1930.
Cobalt Molybdenum, Tantalum, Titanium and Various Rare Metals in 1930.
Gold, Silver, Copper, Lead and Zinc in Montana in 1930.
Lime in 1930.
Manganese and Manganiferous Ores in 1930.
Mica in 1930.
Phosphate Rock in 1930.
Sand and Gravel in 1930.
Secondary Metals in 1930.
Slate in 1930.
Talc and Soapstone in 1930.
Tin in 1930.
Tungsten in 1930.
Stone in 1930.

Report of Investigations:

3118—Explosive Shattering of Minerals as a Substitute for Crushing Preparatory to Ore Dressing. By R. S. Dean and John Gross.
3146—Acidity of Drainage from High Pyritic Coal Areas in Pennsylvania. By R. D. Leitch.
3153—Factors Influencing Flow of Natural Gas Through High-Pressure Transmission Lines. By W. B. Berwald and T. W. Johnson.
3156—Review of Fatalities in the California Petroleum Industry During the Calendar Year 1930. By R. L. Marek.
3157—Washability Data on Certain Coal Beds of Alabama with Special Reference to Sulphur Elimination. By B. W. Gandrud, G. D. Coe and M. F. Thomas.
3158—Official Changes in the Active List of Permissible Explosives and Blasting Devices for December, 1931.
3159—Laboratory Batch Still and Fractionating Column for Production and Study of Lubricating Distillates under Vacuum. By Boyd Guthrie and Ralph Higgins.
3160—The Effect of Oxygen on Gaseous Hydrogen Sulphide Corrosion of Tank Steel. By John M. Devine, C. J. Wilhelm and Ludwig Schmidt.
3161—Official Changes in the Active List of Permissible Explosives and Blasting Devices for January, 1932.
3162—Motor Gasoline Survey, August, 1931, Part I. Specification data. By A. J. Kraemer and E. C. Lane.

Information Circulars:

6077—List of Permissible Mining Equipment.
6548—List of Motors Available to Prospective Builders of Permissible Outfits. By L. C. Ilsley and M. W. Means.
6549—Physical Chemical Properties of Menthane by H. H. Storch.

6550—Milling Methods and costs at the Superior Concentrator of the Engels Copper Mining Co., Plumas County, Calif. By W. I. Nelson.
6551—Milling Methods at the Questa Concentrator of the Molybdenum Corporation of America, Questa, New Mexico. By J. B. Carman.
6557—Hazards to Underground Workers from Inflammable Surface structures Near Mine Openings. By D. Harrington and M. W. Von Bernewitz.
6558—The Importance of Discipline in Mine Safety. By D. Harrington.
6563—Soapstone. By H. Herbert Hughes.
6564—Consumption of Primary Tin in the U. S. during 1930. By John B. Umhau.
6565—Mining Methods and Costs at the Braden Copper Co.'s Mines, Sewell, Chile. By J. S. Webb and T. W. Skinner.
6567—Medical Service, Accident Reports, Compensation, and Welfare at Iron Mines in the Lake Superior Region. By F. S. Crawford.
6569—Geophysical Abstracts No. XXXIV. By Frederick W. Lee.
6570—How to Prevent Death and Injury from Falls to Roof in Coal Mines. By J. W. Paul.
6576—A Tabular Review of State Laws Relating to Taxation and Inspection of Gasoline and Other Petroleum Products. By Arch L. Foster.
6580—Methods and Costs of Mining and Preparing Sand and Gravel at the Plant of the Ward Sand and Gravel Co., Oxford, Mich. By Frederick L. Ward.
6581—Methods and Costs of Mining and Preparing Sand and Gravel at the Clowdy Plant of the Dallas Washed and Screened Gravel Co., Dallas, Texas. By Ralph L. Windrow.
6582—Sand and Gravel Dredging Methods and Costs of J. K. Davison and Bro., Pittsburgh, Pa. By Geo. H. Williamson.
6585—Economic Size of Metal-Mine Airways. By G. E. McElroy.
6586—Mining Practice at the Edwards Mine of the St. Joseph Lead Co., St. Lawrence County, New York. By John B. Knaebel.
6589—Index to Geophysical Abstracts No. XXI to No. XXXII. By Palmer Larson.
6591—The Cost of Delevoping to the Operating Stage and Equipping a Small or Medium-Sized Mine in the Tri-State Lead and Zinc District. By John R. Reigart.
6593—Geophysical Abstracts No. XXXIII. By Frederick W. Lee.
6594—Sampling and Exploration by Means of Hammer Drills. By John B. Knaebel.

Petroleum Field Office, San Francisco:

Recent Articles on Petroleum and Allied Substances.

Governmental, State

Arkansas Geological Survey:

Inf. Cir. No. 1—A Barite Deposit in Hot Springs County, Arkansas.

California State Department of Public Works:

"California Highways and Public Works."

California State Division of Fish and Game, San Francisco:

"California Fish and Game."

California State Division of Water Resources:

Bull. 28—Economic Aspects of a Salt Water Barrier Below Confluence of Sacramento and San Joaquin Rivers.

California State Library:

News Notes.

Connecticut State Geological and Natural History Survey:

Bull. 50—Fourteenth Biennial Report of the Commissioners, 1929, 1930.
Bull 51—The Minerals of Connecticut. By J. F. Schairer.

Illinois State Geological Survey:

R. I. No. 24—Progress Report on the Study of Southern Illinois Silica as a Pottery Material. By C. W. Parmelee.

Indiana State Department of Conservation:
No. 108—Sub-Surface Strata of Indiana. By W. N. Logan.

Kentucky Geological Survey:
Vol. 41, Series 6—Vein Deposits of Central Kentucky and Other Papers. By L. C. Robinson.
Vol. 43, Series 6—After Thirteen Years (Administrative Report). By W. R. Jillson.

Louisiana State Bureau of Scientific Research of the Minerals Division:
Geological Bulletin No. 1—Geology of Iberia Parish. By H. V. Howe and C. K. Moresi.

Mississippi State Geological Survey:
Thirteenth Biennial Report, 1930–1931.

Montana State Bureau of Mines and Geology:
Reprint No. 1—Correlation of Montana Algonkian Formations. By C. H. Clapp and C. F. Deiss.

West Virginia Geological Survey:
Randolph County. By D. B. Reger.

Governmental, Foreign

Canada Department of Mines, Ottawa:
No. 721—Investigations of Fuels and Fuel Testing.

Finland Geological Commission, Helsinki-Helsingfors:
Bulletin.

Geological Survey of Great Britain, London:
Memoirs.

Museo de Historia Natural de Montevideo, Uruguay:
Anales.

New Zealand Geological Survey Branch, Wellington:
Reports.

Ontario Department of Mines, Toronto:
40th Annual Report.

Quebec Bureau of Mines:
Reports.

Ryks Geologisch-Mineralogisch Museum, Leiden (Holland):
Leidsche Geologische Mededeelingen.

Secretaria de Industria, Commercio y Trabajo, Mexico, D. F.:
Boletin Minero.

Transvaal Chamber of Mines, Johannesburg:
Publications.

Societies and Educational Instituions:

Academy of Natural Sciences of Philadelphia:
Proceedings.

American Association of Petroleum Geologists, Tulsa, Okla.:
Bulletins.

American Geographical Society of New York:
"Geographical Review."

American Institute of Mining and Metallurgical Engineers:
Transactions, 1931—General, Petroleum Division, Institute of Metals Division.

American Journal of Science, New Haven, Conn.

American Philosophical Society, Philadelphia:
Proceedings.

Journal of Geology, Chicago, Ill.

Colorado College Publications, Colorado Springs.

Colorado Scientific Society, Denver:
Proceedings.

Journal of Sedimentary Petrology, Fort Worth, Texas.

Journal of Paleontology, Fort Worth, Texas.

Economic Geology, Lancaster, Pa.

Metals and Alloys, New York City.

Mineralogical Society of America, Menasha, Wis.:
"The American Mineralogist."

Mining & Metallurgical Society of America, New York City:
Bulletins.

New York Academy of Sciences, N. Y.:
Annals.

New York State Museum, Albany:
Circular 7—Recent Natural Gas Developments in South Central New York.

Northwest Scientific Association, Cheney, Wash.:
"Northwest Science."

Southern California Academy of Sciences, Los Angeles:
Bulletins.

University of California, Berkeley.
Publications in Geology:
Vol. 20, No. 11—Paleozoic Eruptive Rocks of the Southern Klamath Mountains. By N. E. A. Hinds.
Vol. 20, No. 12—A Review of the Rhinoceroses with a Description of Aphelops Material from the Pliocene of Texas. By W. D. Matthew.
Vol. 21, No. 5—The History and Character of Volcanic Domes. By H. Williams.
Vol. 21, No. 6—A New Genus of Artiodactyla from the Clarendon Lower Pliocene of Texas. By R. A. Stirton.
Vol. 21, No. 7—The Fossil Passerine Birds from the Pleistocene of Carpinteria, California. By A. H. Miller.

Publications in Geography:
Vol. 5, No. 4—Lower California Studies, IV, The Natural Landscape of the Colorado Delta. By F. B. Knippen.
Vol. 5, No. 5—Dry Climates of the U. S., II, Frequency of Dry and Desert Years, 1901–1920. By R. J. Russell.

Seismological Society of America, Stanford University:
Bulletins.

Library of Congress, Washington, D. C.:
Monthly Check-List of State Publications.

Washington State College:
Vol. 14, No. 5—The Development of an Electro-Hydrometallurgical Process for Copper Flotation Concentrate. By C. F. Floe and A. E. Drucker.

Western Society of Engineers, Chicago:
Journals.

Australian Museum, Sydney:
Records.

Geological Society of London:
Abstracts from the Proceedings.

Institution of Mining and Metallurgy, London, E. C., 1:
Bulletins.

Philippine Journal of Science, Manila.

Ryojun College of Engineering, Ryojun, Manchuria:
Memoirs.

Books.

American Mining and Metallurgical Manual, 1932 edition.
Ayer's Newspapers and Periodicals Director, 1932.
Standard Metal Directory, 1931.
The Mineral Industry during 1930. Vol. XXXIX. Edited by G. A. Roush.
Flotation. By A. M. Gaudin.
Symposium on Effect of Temperature on Metals. By A. S. T. M. & A. S. M. E.
Physics of the Earth—I Volcanology. Bull. 77, National Research Council.
Figure of the Earth. Bull. 78, National Research Council.
Meteorology. Bull. 79, National Research Council.
Age of the Earth. Bull. 80, National Research Council.
The Grand Coulee. By J. H. Bretz.
Birth Stones. By Tiffany & Co.
Conservation in the Department of the Interior. By R. L. Wilbur and W. A. Du Puy.
Prospecting for Minerals. By S. H. Cox.
Prospector's Field-Book and Guide. By H. S. Osborn and M. W. von Bernewitz.
Prospector's Handbook. By J. W. Anderson.
Hydraulic and Placer Mining. 3d Edition. By E. B. Wilson.
Soil Mineralogy. By F. A. Burt.
Precious and Semi-Precious Stones. By M. Weinstein.

John Hays Hammond Public Mining Library:

Text-Book of Mining Geology. By James Park.
Mineral Valuation. By Henry Louis.
Principles and Practice of Mine Ventilation. By D. Penman and J. S. Penman.
Oil and Retortable Materials. By G. W. Halse.
Aids in Practical Geology. By G. A. J. Cole.
Mine Ventilation and Ventilators. By M. H. Haddock.
Dictionary of Spanish, English Mining and Metallurgical Terms. By E. Halse.

Maps.

U. S. Geological Survey Topographic:

California:

Angle Quadrangle, Los Angeles County.
Black Butte Quardrangle, Los Angeles County.
Casa Desierta Quadrangle, Los Angeles County.
El Mirage Quadrangle, Los Angeles County.
Joshua Quadrangle, Los Angeles County.
Lancaster Quadrangle, Los Angeles County.
Lovejoy Springs Quadrangle, Los Angeles County.
Llano Quadrangle, Los Angeles County.
Oban Quadrangle, Los Angeles County.
Ravenna Quadrangle, Los Angeles County.
Roosevelt School Quadrangle, Los Angeles County.
Tierra Bonita Quadrangle, Los Angeles County.
West Alpine Butte Quadrangle, Los Angeles County.
Wilsona Quadrangle, Los Angeles County.
Arvin Quadrangle, Kern County.
Bear Mountain Quadrangle, Kern County.
Conner Quadrangle, Kern County.
East Elk Hills Quadrangle, Kern County.
Millux Quadrangle, Kern County.
Oildale Quadrangle, Kern County.
Rosedale Quadrangle, Kern County.
Weed Patch Quadrangle, Kern County.
West Elk Hills Quadrangle, Kern County.
West of Lethent Quadrangle, Kern County.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

American Petroleum Institute Bulletin, New York City.
Architect and Engineer, San Francisco.
Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Commerce Reports, Washington, D. C.
Commonwealth, San Francisco.
Colorado School of Mines, Golden, Colorado.
Cooper-Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Industrial Employment Information Bulletin, Washington, D. C.
Lubrication, The Texaco Co., New York City.
Mining Congress Journal, Washington, D. C.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil Bulletin, Los Angeles.
Oil, Philadelphia, Pennsylvania.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pit and Quarry, Chicago.
Pacific Purchaser, San Francisco.
Petroleum Times, London, E. C. 2.
Petroleum Age, Chicago.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.
Union Oil Bulletin, Los Angeles.

Newspapers.

The following papers are received and kept on file in the library:

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.
California Oil World, Los Angeles, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Daily Sun, Colusa, California.

Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inland Oil Index, Casper, Wyoming.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of Mining in California was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of Mining in California, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of Mining in California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

Supplement to Mining in California, April, 1932, Quarterly Chapter of State Mineralogist's Report XXVIII

PLACERS OF SOUTHERN CALIFORNIA

By R. J. SAMPSON, Mining Engineer

In the region south of Tehachapi Pass and extending to the Mexican border, semi-dry and dry washing methods of working placer deposits are used generally on account of the scarcity of water.

A list of the areas in which this work has been done in the past, together with a brief description of some of the more important developments now under way, is given below.

IMPERIAL COUNTY

The most productive deposits are known as the Mesquite, Picacho and Potholes. These are dry placers, although the Picacho deposits extend eastwardly, almost to the Colorado River. The gold in these districts came from the quartz stringers in the schists and slates of the Cargo Muchacho and Chocolate ranges of mountains, being brought down and concentrated in the gulches and washes by erosion.

Mesquite Placers are located 6 miles north of Ogilby and in the area east toward the Chocolate Mountains.

A number of dry washers have been working in these deposits for the past few months. No reliable information as to the values recovered is available but sales of gold in small amounts are being made.

Picacho Placers. These deposits extend some 6 miles in and east-west direction, from a point about thirty miles north of Yuma and from two to five miles south of the Colorado River.

In the past much dry washing has been done and there are now several small dry washers in operation in this area.

In the Carissa Wash, some 31 miles north of Yuma, plans are now being formulated for the installation of a steam shovel and sluice boxes. The gravel is to be washed by water pumped from the Colorado River, about three miles to the north. The gravel lies in the dry stream bed which here is almost a closed basin, from 200 to 400 feet wide and about 2500 feet long, and on the hillsides and gulches on the west side of the wash. In the past these gulches have all been dry washed, while on the points of the ridges between, good values are known to exist to a depth of at least two feet, no deeper prospecting having yet been done. Bedrock is rhyolite on the west which apparently dips under a conglomerate, in the wash itself.

Potholes Placers are situated 10 miles northeast of Yuma and several miles west of Laguna Dam. This district has a reported production of $2,000,000 which, it is stated, was recovered by dry washing, some four hundred to five hundred Mexicans having been at work for several years, in the past. At present a few small dry washers are being operated on these deposits.

INYO COUNTY

Mazourka Canyon Placers, situated on the west slope of the Inyo Mountains, east of Independence, have been practically worked out by dry washers.

KERN COUNTY

Black Mountain and Grubstake Dry Placers are on the south slope of Black Mountain, near the head of Last Chance Canyon, about 13 miles northeast of Cantil. These have long been worked with dry washers. Several of these machines are now in operation and variable reports have been circulated as to their success.

Brittan and Murphy Placer Mine, consisting of 12 claims, is in Sand Canyon, which is tributary to Goler Canyon from the northwest. They include a portion of Goler Canyon and extend up Sand Canyon about three thousand feet. The ground is owned by B. E. Carroll, Sam Mingus and Wm. Nozzer and is leased to V. E. Britton and Dan M. Murphy, of Muroc, California.

This deposit consists of alluvial slopes on each side of the canyon and gravel in the bottom of the canyon. The canyon averages about 200 feet in width and the depth to bedrock is approximately 50 feet. Four shafts have been sunk to bedrock in the canyon and drifts and crosscuts driven. This work is reported to have developed an area 500 feet long by 200 feet wide by 50 feet deep. On the northeast side of Sand Canyon several short tunnels were driven years ago. These were driven on an andesitic bedrock.

The gravel which is angular and sub-angular to round, was mined some six feet above this bedrock. This material is largely alluvium with some gravel evidently deposited by intermittent stream action. Evidently this material extends to the top of the ridge, on the sloping bedrock which apparently has been faulted along the line of Sand Canyon. These side hill gravels are partially cemented whereas material in the canyon is wholly unconsolidated. On the west side of the canyon the crest of the ridge is partially covered with gravel and alluvium to a depth of about 6 feet. It is proposed to work all of these deposits, average value of which is said to be 45 cents per yard.

On the west side of the canyon near the crest of the ridge, about 100 feet above the bottom of the canyon, the following test or sampling plant has been installed:

Material to be delivered in trucks, loaded by power shovels, passes over 4″ grizzly made of railroad rails, to 60-ton bin. Bin feeds from 4 openings, belt feeders to conveyor to 4′ x 14′ trommel with small concrete mixer at feed end to break up cemented gravel. Trommel has ½″ and 16-mesh screens. Material through ½″ and +16-mesh goes to sluice box. Sluice box is made of No. 10 gauge steel 20″ x 20″ x 40′ long. First section has burlap on bottom with ¼″ and ½″ screens over it, the other two sections having steel riffles of the Hungarian type. The minus 16-mesh product goes to incline screw conveyor and an Overstrom Universal table. Tailings from both sluices and table go to another trommel with 16-mesh screen (for dewatering); thence to tailings stacker belt. Dewatering tanks have been temporarily provided to be eventually replaced by Dorr thickeners.

Water is to be obtained from two wells in Goler Canyon about two thousand feet from the plant and one hundred feet below it. A 100,000-gallon concrete reservoir has been built. Eight-inch plunger pumps are used at the wells and a triplex pump boosts the water to five 12′ x 6′ water tanks through a 4″ line. Gas engines are to be used throughout for power. Capacity about 150 yards per day.

Ten men are employed installing plant.

Goler Placers. These deposits occur on the south slope of the El Paso range of mountains, in Goler Canyon and the gulches tributary to it. They are 25 miles northeast of Mojave and 10 miles west of Randsburg. On the hillsides they consist largely of alluvium with some rounded gravel, evidently deposited by intermittent streams, while in the main washes the rounded gravel is in excess. Haley[1] mentions a short channel which came in through Red Rock Canyon where it was joined by another from the west, by way of Jawbone Canyon. He states that the shore line can be traced clear through by way of Goler and Summit Diggings and through Coolgardie, but dips under the wash near Barstow.

Spark Plug Group, consisting of 5 claims, is in Benson Gulch, just west of Goler Canyon. Elevation at workings is 3020 feet or 550 feet above the new pumping plant at Goler. Owners, J. D. Voss, Paul Voss, J. D. Ross, ------ Golett, of Garlock and ------ Hill, of Sacramento; under lease to Ben Howard, with whom there is associated H. Anderson, G. Anderson, F. Askew and H. Griggs, all on the ground.

Benson's Gulch has a general east-west trend and is about 1½ miles long. Near its head where the present work is being done, it is quite steep. The deposit lies in the bottom of the gulch and on the north side, the south side being a solid rock slope.

The material is angular, sub-angular and rounded. In places it has been stratified into thin beds by intermittent stream action. Its thickness varies from 6 to 18 feet, with an estimated average of 8 feet. Bedrock is the monzonite basement of the district, which dips to the south and is overlaid by the rock on the south side of the gulch, which appears to be andesite. On account of its dip the shovel must take about three feet of the bedrock with the gravel. This decreases the shovel's capacity as well as increasing cost of repairs.

Operations were begun about three-quarters of a mile above the mouth of the gulch and have proceeded about one hundred feet above this point, some 800 yards having been treated. It has been estimated that there are 350,000 cubic yards available in the next one thousand feet up the gulch, average gold content of which has been placed at 60 cents per yard. Average recovery from yardage treated to date has exceeded this figure. The greater part of the gold is fairly coarse and rough. Average pieces weigh from 5 to 24 grains, while one 3-ounce nugget has been found. A large percentage of the gold is coated on at least one side with amalgam and globules of hard mercury were observed on several pieces. The operators contend that this is native 'quick.' In view of past operations here, this would appear rather doubtful.

[1] Haley, Chas. S., Calif. State Min. Bureau, Bull. 92, p. 156.

A P and H gasoline shovel with a $\frac{5}{8}$-cu. yd. dipper digs the gravel and conveys it direct to the feed hopper on a Pierce Gold Dredge. From the hopper the material goes to a trommel about 4′ x 16′, with $\frac{3}{4}''$ openings, the fine gravel passes into apron sluices $2\frac{1}{2}'$ x 4′; thence to about 25′ of sluice $2\frac{1}{2}'$ wide, equipped with Hungarian riffles. The coarse material is discharged onto an inclined belt which stacks the tailings behind the machine. The apparatus is mounted on caterpillar tractors and is moved by its own gas engine power.

A tailings pond has been built about one hundred feet below the lower end of the workings and the water here recovered is returned by centrifugal pump. Water is supplied by the Yellow Aster pumping plant, through a 4″ line, about $1\frac{1}{4}$ miles long.

Kern River Placers. These deposits are distributed along the river from Democrat Hot Springs, 13 miles south of Isabella to Hobo Hot Springs, a distance of 12 miles.

The gold is contained in the alluvium of the slopes on each side of the river, also a few small gravel benches, and in the crevices and underneath large boulders in the stream bed itself. A small dredge has been operated in the river valley at Keyesville.

In the past eighteen months, some small suction pumps have been used to raise gravel from the bottom of the river and from around the base of the large boulders, while for many years intermittent operations in the crevices of the river bedrock have been carried on in a small way.

Sunset Placer Mine, comprising 40 acres is located on the north bank of the Kern River, 29 miles east of Bakersfield. Benches of gravel, which have been worked in the past by ground sluicing, occur on the north bank of the river in this area. Considerable gold is stated to have been recovered from these operations. The gravel is 4′ to 8′ thick, on a granite bedrock.

Piute and Greenhorn Mountain Deposits. There are small amounts of gravel in the gulches of the Piute and Greenhorn Mountains. Some washing in a small way has been done here in the past.

Randsburg or Norden Placer is in Sec. 22, T. 29 S., R. 40 E., about 2 miles north of Randsburg and the north base of the Rand Mountains.

Sixteen shafts, ranging from 15 to 34 feet in depth were sunk in this area. Eleven of them reached bedrock. Reported values from 250 yards of material taken from these shafts gave 80 cents per yard for 4′ to 16′ of overburden, and $2 per yard for the underlying gravels which average 12′ in thickness.

The gravels are unassorted, containing many large boulders. They are tightly packed and locally cemented with 'caliche.' The bedrock is schist.

The gold recovered is worth $18.48 per ounce. The average size is such that ten colors yield a value of one cent. Pieces having values as high as 20 cents were obtained in the sampling. It is not confined to definite horizons but is rather evenly distributed throughout the gravel.

In 1923, a dredge having a capacity of 500 to 750 yards per day was installed in a 40′ by 50′ hole made for the purpose. Water was purchased from the Yellow Aster Mining Company at $1.25 per 1000 gallons, but sufficient water could not be put into the hole to flloat the dredge.

More recently a Pierce Gold Dredge (dry land dredge) was operated here for a brief period and then moved to Benson's Gulch in the Goler area.

Nieto and Feldman Group of Claims, consisting of 3 claims, is in the Atolia District, in Sec. 30, T. 30 S., R. 41 E., M. D. M., and comprises 320 acres. Owner, John Nieto, Seaside Terrace, Santa Monica, California, and Frank Feldman, Randsburg, California. Under lease to E. E. Brown, Wm. Morse and ------ Wilhelm, of Los Angeles.

This deposit was primarily worked for tungsten and is a part of the 'Spud Patch.' During the war a large part of the surface was turned by hand. More recent work, largely consisting of sampling, is reported to show that bedrock is at a depth of from 15′ to 18′ and that in addition to the scheelite the alluvium contains from 75 cents to $1 per yard in gold. These values occur in alluvium of comparatively recent age, the deeper alluvium having been found barren in a 250′ shaft which was sunk just southeast.

It is reported that the present lessee has sampled the property by post holes and pits, developing some 2,000,000 cubic yards, with an average value of 75 cents to $1 in gold.

The following plant was used for running the samples taken:

Fordson tractor engine, chain drive to double drum dragline hoist; to 3″ grizzly; chain bucket elevator to 25-ton bin; belt to 2′ by 6′ double deck trommel, ½″ and 8-mesh; screenings to 12″ Ainlay Bowl Gold Saver; to 2 sets of shaking sluices, each 3′–4′ wide by 6′ long, made of 16-gauge sheet steel; tails to dewatering drag belt and belt tailings stacker. Recovered water is pumped to 6′ Allen Cone by 1½″ centrifugal pump; clear water overflow to fresh water tank. This plant is run by 15-h.p. International gas engine.

The results having been satisfactory, it is now planned to install a 36″ Ainlay bowl which is expected to handle 250 yards per day.

Red Rock Canyon Placers. These deposits occur in Iron Canyon and its tributaries. This canyon is tributary to Red Rock Canyon from the northeast.

Ricardo Placer Mines, comprising 3000 acres of patented placer claims, are situated on both sides of Iron Canyon about 25 miles north of the town of Mojave. Elevation 2300′. Owner, Rudolph Hagen, Ricardo, California. Five hundred acres under lease to Iron Canyon Mining Company, L. E. Wisenberg and L. P. Conway, 1236 Amherst Street, Los Angeles.

These deposits extend along the hills on each side of Iron Canyon for several miles. The formation consists of a series of beds of conglomerate sandstone and lava flows. The conglomerates at the base of these hills are free from volcanic pebbles but consist of many kinds of rock some of which are foreign to the district. The richest gulch, worked during 1894–1896, was known as Bonanza and is two miles east of Ricardo. The gold was found not only in the gulch but on the slopes of the hills above. These diggings were worked by dry washers. In more recent years many attempts have been made to sink to bedrock in Iron Canyon but all have failed due to excessive water flow.

The present company put down a well expecting to get water for hydraulic mining of the gravels. Sufficient water for this purpose was not developed and they are now planning to install a steam shovel

and sluice boxes. Water available is reported to be from 300 to 400 gallons per minute.

They have sunk a shaft 40 feet deep, 500 yards north of the Owens Valley highway in Red Rock Canyon. A few boulders and some quicksand are reported to have been encountered in this shaft, the bottom of which is 15 feet above bedrock. Water stands at 20 feet below the collar. Depth to bedrock varies from 38 to 55 feet. They estimate that the gravels contain an average value of 35 cents per yard.

Equipment consists of two 3-cylinder, 125-h.p. American-Madsen diesel engines; two 900-g.p.m. Byron Jackson single-stage centrifugal pumps and 75-h.p. generator; 10″ two-stage rotary pump direct connected to 30-h.p. G E motor, which is to pump from Red Rock Canyon to a reservoir. The 900-gallon pumps force the water from the reservoir to the sluices up the canyon, through 4000 feet of 8″ pipe.

Nine to 12 men have been at work here but they are now shut down while revising plans.

Summit Diggings. These deposits occur at the foot of the south slope of Summit range of mountains, 6 miles east of Goler and 6 miles north of Randsburg. They are described under the names of the two principal operations.

Oro Fino Placer (now Olympic and Miller groups) consists of 160 acres in Kern County and 30 acres in San Bernardino County, just east of Owenyo branch of the Southern Pacific Railroad, 6 miles north of Randsburg. Owners, D. A. Woodruff, 323 South Hancock Street, and C. E. Collins, 2414 Cabot Street, Los Angeles.

This property has been worked intermittently for thirty years and several hundred feet of tunnels have been driven on bedrock, the gravels having been worked in dry washers.

The unassorted gravels, containing many boulders, are widespread and not related to recent streams. They are stated to average 18 feet in thickness and are compact but only lightly cemented. Of this thickness only about 6 feet immediately above bedrock has been taken in most of the past operations. Present operators state that this 6 feet will average something over $1.50 per yard. The gold is fairly coarse, showing pieces up to $4.25 in value.

In 1923 a Stebbins dry concentrating plant, having a capacity of 150 yards of gravel per shift was installed here. A total of about 8000 yards was treated before operations were suspended for unknown reasons. Present operations consist of driving bedrock tunnels. Gravels from these tunnels are passed over 1″ screen, undersize to 12′ sluice box, 6″ wide, with ½″ riffles and burlap.

Water is obtained from a well on a quartz claim just east of the placer ground. This well is reported to make 1400 to 1500 gallons daily.

Three men are employed.

Summit Gold Placers comprising 1640 acres in Secs. 1 and 12, T. 29 S., R. 40 E., and Sec. 6, T. 29 S., R. 41 E., M. D. M., 6 miles east of Goler and 6 miles north of Randsburg. Elevation 3300′. Owner, A. L. Cram, on the property. Formerly owned by Western Placer Mines Company. For description of this company's operations see State Mineralogist's Report XXV, pp. 48–49.

The gravels consist of reconcentration of the older alluvium in recent water courses. They are unassorted, varying from 2 to 10 feet

in thickness and containing many large boulders. The values occur uniformly distributed throughout the gravel. The gold is fairly coarse. Samples from test holes are reported to carry from 35 cents to $1 per cubic yard. Large scale operations here were abandoned after the treatment of several thousand yards. It was reported that recovery of the gold was difficult due to the large amount of black sand in the gravel.

Present operations are confined to a few individuals who are operating dry washers on the gravels above and to the east of the shovel cut made by the former operators.

LOS ANGELES COUNTY

Gold[1] was first discovered in Los Angeles County in 1834 and the placers of San Francisquito, Placerita, Casteca, Palomas and Santa Felicia canyons were worked between the years of 1834–1838 by the priests of the San Fernando and San Buena Ventura missions. The placers of San Gabriel Canyon were worked by the priests of San Gabriel Mission and native Californians until the discovery of gold by Marshall in 1848 at Sutter's Mill.

Placerita Canyon Deposits occur 12 to 15 miles northwest of Newhall. For these deposits see State Mineralogist's Report IX, pp. 200–203.

San Francisquito and Bouquet Canyon Deposits (see State Mineralogist's Report XI, p. 248) are situated north of Saugus. These deposits have been the scene of much activity during the past eighteen months. This activity has been due largely to their proximity to Los Angeles and the present unemployment situation. The rush of water unleashed by the failure of the St. Francis dam eroded the sides of the canyon, depositing thousands of tons of angular gravel and a little gold in the creek bed. The discovery of this gold caused some excitement and has resulted in numerous people attempting to wash the gravels of the present stream, as well as some bench gravels on the hillside above.

San Gabriel Placers. These deposits occur primarily as high gravel benches on each side of the canyon, scattered over a length of several miles. The auriferous gravel in the canyon itself is probably a reconcentration of these bench gravels by recent streams.

In the past year or so there has been much activity here in a small way. It is estimated that there are now from 500 to 1000 people working in the canyon and on the benches.

Bibl: State Mineralogist's Report VIII, p. 340; Bull. 92, pp. 154–155.

Temescal Ranch Deposit, comprising some 3000 acres, lies between Devils Canyon on the northwest, Palomas Canyon on the northeast and Santa Felicia Canyon on the east and south. It is contained in an area of some six square miles. It is 14 miles northeast of the town of Piru, the greater portion of it is in Los Angeles County. Owner, E. L. Doheny, Beverly Hills, California.

This is a most extensive deposit. The sand, gravel and sandy clay appear to form a crescent-shaped range of hills which parallel

[1] Rept. XXIII of the State Mineralogist, p. 291.

Devils Canyon almost to its head and there swings southeast along the southwest side of Palomas Canyon. For a distance of 3½ miles along Devils Canyon these hills which are yellowish-brown in color, predominate, although occasionally the underlying Tertiary gray clays have been exposed by erosion. To the southeast all of the exposed country consists of Tertiary clays, while to the northeast, Violin Canyon is flanked by a red granitic mountain.

These hills have been cut deeply by Devils Creek and other smaller streams. In places they rise in almost sheer cliffs for 300 feet before breaking to a more gradual slope, rising to a total height of between 600 and 700 feet above the bottom of Devils Canyon. The average thickness of the gravel beds is reported to have been estimated by engineers as 300 feet. The material consists of sand, sandy clay and sub-angular to rounded gravel. (It was probably deposited here by some ancient stream which flowed through the Mt. Pinos and Frazier Mountain country in a southeasterly direction).

In Mine Creek about one mile above its mouth several tunnels, aggregating about 1000 feet in length, have been driven into these deposits. Apparently it was too low grade to be profitably worked by this method. No other operations have here been attempted, although preliminary plans for hydraulic mining on a large scale have been made.

Canyon Placer Mine, comprising 640 acres, is located along Texas Canyon 2 miles northeast of Texas Canyon Mine and 12.8 miles northeast of Saugus. Elevation 2350′. Owner, W. H. Cruzan, Newhall, California.

The auriferous gravel deposits are on the north side of the canyon and their general course is northeast, being one-quarter of a mile wide and two miles in length.

In 1927 a high bench was being worked. Water was secured from a dam in Texas Canyon one mile above the workings. The gravel was 8 to 10 feet thick here. The gravel was shoveled into a sluice from which it passed through a revolving drum, then onto a fine screen before going to a large rocker driven by a 3-h.p. gas engine. The gold recovered was quite fine and due to limited water supply could only be worked during the winter months.

Texas Canyon Placer Mine, comprising Texas and Woodrow Group of claims, consisting of 320 acres, is located in Texas Canyon 10 miles northeast of Saugus. Last known owners, John Caspar and Robert Heinze, Los Angeles.

On the north side of the canyon a gravel bench some 6 to 8 feet thick has been worked for about a quarter of a mile in length. The channel has general northeast course. The gold is quite fine. The gravel is composed of metamorphic rocks and some quartz. Various attempts have been made to work the deposit by pumping water from the canyon. Work has been carried on intermittently due to scarcity of water.

MONO COUNTY

Conroy Ranch Placer comprises 400 acres of patented land located on the north shore of Mono Lake and to the west of Mono Diggings. Owner, Richie Conroy, Mono Lake, California.

The gravel on this property is reported to carry 25 cents per yard and covers the whole area of the ranch. It is reported that the property was formerly drilled for dredging ground.

Dog Creek Placer, consisting of 280 acres, is on Dog Creek, in Secs. 2, 3, 11, 10 and 15, T. 3 N., R. 25 E., and Sects. 34 and 35, T. 4 N., R. 25 E., M. D. M., 9 miles south of Bridgeport and 60 miles north of Laws. Owner, Wm. Bailey, Bridgeport, California; under lease and bond to Dog Creek Placer Mining Company, C. W. Stone, president; W. B. Lenhart, secretary, Bridgeport, California.

This deposit was discovered in 1870 and had been intermittently worked until 1930 when it was acquired by present company.

Primary loose gravels on Dog Creek occur on a basaltic bedrock and the pay is contained in the 2 to 4 feet next to the bedrock. This pay gravel is buried under from 4 to 10 feet of secondary gravel.

Open cuts, pits and prospect shafts along the creek are reported to have exposed 2,000,000 cubic yards of gravel which carry average values of 50 cents per yard.

Present company operations are conducted as follows: Dragline delivers gravel to hopper; thence to revolving screen; 1″ oversize to waste; fine material to sluices. Water is obtained through 10″ pipeline, under 200 feet head from Dog Creek.

Virginia and Dog Creek Placers. Owner, A. J. Warrington, Bridgeport, California. These deposits, consisting of 440 acres, are in Secs. 2, 11 and 14, T. 3 N., R. 25 E., 60 miles north of Laws and 9 miles south of Bridgeport. Elevation 7000 feet. Operations were carried on here from July, 1929, to July, 1931, by Quincy Stevens, of Los Angeles.

In the 18,000 feet of channel on this property the pay is contained in from 2 to 4 feet of gravel immediately above the basaltic and andesitic bedrock. This is overlain by from 6 to 10 feet of gravel which carries no values. This bedrock gravel shows from 15 to 20 colors to the pan, some of it being coarse, as large as wheat grains. Reported to carry from 50 cents to $2 per yard.

Area which has been worked by dragline is 150 feet long by 100 feet wide by 15 feet deep. Material is delivered by Link-Belt diesel engine shovel, 1¼-cu. yd. dipper, to hopper; to revolving screen, 1″ openings; oversize by belt conveyor to waste; through size to sluice boxes, capacity 500 cubic yards daily.

The property has merit. With proper equipment and water from Dog Creek could probably be successfully operated.

Walker River. Deposits of auriferous gravels occur in the head water area of Walker River near Bridgeport.

SAN BERNARDINO COUNTY

Coolgardie Placer Deposits are situated 15 miles north of Barstow. The nearest available water, in quantity, is some fifteen miles distant.

These deposits are in a broad desert valley and were evidently washed down from the granitic ranges to the north and by an ancient river which came in through Red Rock Canyon, by way of Summit Diggings and Goler.

Much dry washing has been done here since 1900.

Bibl: State Mineralogist's Report XV, p. 817; Bull. 92, p. 156.

Camp Rock Placers are in Sec. 28, T. 7 N., R. 3 E., in the Bessemer Mountains, 25 miles northeast of Box S ranch and 47 miles (by road) from Victorville.

This deposit is on the detrital slope at the foot of the Bessemer Mountains on the southwest side. These mountains consist entirely of granite. The drainage is to the southwest into a valley which also receives drainage from the southwest slope of the Ord Mountain. A narrow drainage channel has been prospected for about 1000 feet of its length. The granitic bedrock appears to vary from 15 to 25 feet below the surface.

This work is reported to have been done in gravel which carried from $1 to $1.50 per yard.

Scarcity of water seems to have presented an insurmountable obstacle to operations.

Goldstone District is some 33 miles north of Barstow and about 18 miles north of Coolgardie. Erosion of the gold veins of this district has resulted in the deposition of auriferous alluvium and gravels in the gulches. Some dry washing was done here in the early part of this century.

Hamberger Placers are located 15 miles east of Atolia. This ground is all owned by private interests.

Holcomb Valley Placers lie principally in T. 3 N., R. 1 and 2 E., S. B. M. The deposits are near the top of the San Bernardino Mountains north of Bear Lake.

The gold-bearing material is angular granitic detritus containing very few washed or rounded stones. This 'gravel' is overlain by from 4 to 8 feet of light, loamy material, while the substratum contained more clay and was also richer in gold.

This was one of the early gold discoveries in the county, about 1860. In 1894 an English concern attempted operations on a large scale but apparently these operations did not pay.

Bibl: State Mineralogist's Report XV, pp. 798–799.

Old Woman Springs District is about 50 miles east of Victorville, just east of Lucerne Valley and in the vicinity of the Emerson Mine. It is known as the *Maumee Placer.*

Recent attempts to dry wash the alluvium and unassorted gravels of this area, on a large scale, apparently have failed.

VENTURA COUNTY

Lockwood Valley Placers are about 50 miles northeast of Saugus and about 18 miles west of Gorman.

These gravel deposits border all the high peaks of crystalline rocks and are particularly extensive along the head of Piru Creek between Lockwood Valley and Rays Creek. The gold has undoubtedly been derived from the quartz veins in the schists nearby. Beginning about 2½ miles above the mouth of Lockwood Creek on the Piru are a series of terraced gravel deposits extending in a westerly direction to San Quelmo Canyon (about 15 miles) which are said to carry everywhere more or less gold. Desultory mining has been carried on here for

many years. These gravels seem to have been deposited by an ancient stream which diverged from the present course of Piru Creek more toward Mt. Pinos. South of the Piru, at this point there are no gold-bearing gravels. Farther down the Piru the gulches which head in the Alamo Mountain also contain gold.

Bibl: State Mineralogist's Report XII, p. 494.

For further information regarding placer deposits in southern California, reference should be made to California State Mining Bureau Bulletin 92, Gold Placers of California; Bulletin 95, Geology and Ore Deposits of the Randsburg Quadrangle; and the State Mineralogist's Reports on the various counties.

o

94259-A 6-32 3M

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the office of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; Santa Maria; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states, and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	—
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
**Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	----
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period 1917–1918, Fletcher Hamilton:	
Mines and Mineral Rosources of Nevada County, 270 pp., paper	.75
Mines and Mineral Resources of Plumas County, 188 pp., paper	.50
Mines and Mineral Resources of Sierra County, 144 pp., paper	.50

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	$1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, **May, **June, **July, August, September, October, **November, December, 1922	Free
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.25
April, 1925, Mines and Mineral Resources of Calaveras. Merced, San Joaquin, Stanislaus and Ventura Counties	.25
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	.25
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.25
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.25
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.25
October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.25
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.25
July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	.25
October, 1927, Mines and Mineral Resources of Mono County	.25
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.25
April, 1928, Mines and Mineral Resources of Mariposa County	.25
**July 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.25
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	.25
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.25
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.25
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.25
Chapters of Twenty-sixth Report of the State Mineralogist 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.25
April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	.25
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	$0.25
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative effects in Concrete	.25
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifer of the Kreyenhagen Shale. Geology of Santa Cruz Island	.25
July 1931, Mines and Mineral Resources of Yuba and San Bernardino Counties, Feldspar, Silica, Andalusite, and Cyanite Deposits of California. Andalusite in Mono County. Trinity-Klamath River Fish and Game District affects Mining. U. S. Mint Aids Prospectors	.25
October, 1931, Mines and Mineral Resources of Alpine County. Geology of San Jacinto Quadrangle South of San Gorgonio Pass. Mining Activity in Inyo and Mono Counties	.25
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.25
Subscription, $1.00 in advance (by calendar year, only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, June, **July, **August, **September, **October, November, **December, 1919	Free
January, February, March, April, **May, June, July, **August, September, October, November, December, 1920	Free
January, **February, **March, **April, May, June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1922	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1923	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, May, June, July, August, September, October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
January-February-March, April-May-June, July-August-September, 1930 (Published quarterly beginning July, 1929.)	Free

BULLETINS

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 1. A Description of Some Desiccated Human Remains, by Winslow Anderson. 1888, 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of Californian Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887.)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means. 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms. 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
**Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	----
**Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	----
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	$0.50
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 29. Mineral Production of California for Sixteen Years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by Wm. Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 48. Mineral Production of California for Twenty Years, by Charles G. Yale. 1906	----
**Bulletin No. 49. Mines and Minerals of California for 1906, by Charles G. Yale. 34 pp.	----
Bulletin No. 50. The Copper Resources of California, 1908, by A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorne and J. A. Edman. 366 pp., 74 illustrations. (Revised edition.)	$1.00
**Bulletin No. 51. Mineral Production of California, by Counties, 1907, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 52. Mineral Production of California for Twenty-one Years, by D. H. Walker. 1907. Tabulated sheet	----
**Bulletin No. 53. Mineral Production of California for 1907, with County Maps, by D. H. Walker. 62 pp.	----
**Bulletin No. 54. Mineral Production of California, by Counties, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 55. Mineral Production of California for Twenty-two Years, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 56. Mineral Production for 1908, with County Maps and Mining Laws of California, by D. H. Walker. 78 pp.	----
**Bulletin No. 57. Gold Dredging in California, by W. B. Winston and Chas. Janin. 1910, 312 pp., 239 illustrations, 10 maps	----
**Bulletin No. 58. Mineral Production of California, by Counties, by D. H. Walker. 1909. Tabulated sheet	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 59. Mineral Production of California for Twenty-three Years, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 60. Mineral Production for 1909, with County Maps and Mining Laws of California, by D. H. Walker. 94 pp.	----
**Bulletin No. 61. Mineral Production of California, by Counties, for 1910, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 62. Mineral Production of California for Twenty-four Years, by D. H. Walker. 1910. Tabulated sheet	----
**Bulletin No. 63. Petroleum in Southern California, by P. W. Prutzman. 1912, 430 pp., 41 illustrations, 6 maps	----
**Bulletin No. 64. Mineral Production for 1911, by E. S. Boalich. 49 pp.	----
**Bulletin No. 65. Mineral Production for 1912, by E. S. Boalich. 64 pp.	----
**Bulletin No. 66. Mining Laws of the United States and California. 1914, 89 pp.	----
**Bulletin No. 67. Minerals of California, by Arthur S. Eakle. 1914, 226 pp.	----
**Bulletin No. 68. Mineral Production for 1913, with County Maps and Mining Laws, by E. S. Boalich. 160 pp.	----
**Bulletin No. 69. Petroleum Industry of California, with Folio of Maps (18 by 22), by R. P. McLaughlin and C. A. Waring. 1914, 519 pp., 13 illustrations, 83 figs. [18 plates in accompanying folio.]	----
**Bulletin No. 70. Mineral Production for 1914, with County Maps and Mining Laws. 184 pp.	----
**Bulletin No. 71. Mineral Production for 1915, with County Maps and Mining Laws, by Walter W. Bradley. 193 pp., 4 illustrations	----
**Bulletin No. 72. The Geologic Formations of California, by James Perrin Smith. 1916, 47 pp.	----
**Reconnaissance Geologic Map (of which Bulletin 72 is explanatory), in 23 colors. Scale: 1 inch = 12 miles. Mounted	----
**Bulletin No. 73. First Annual Report of the State Oil and Gas Supervisor of California, for the Fiscal Year 1915–16, by R. P. McLaughlin. 278 pp., 26 illustrations	----
**Bulletin No. 74. Mineral Production of California in 1916, with County Maps, by Walter W. Bradley. 179 pp., 12 illustrations	----
**Bulletin No. 75. United States and California Mining Laws. 1917, 115 pp., paper	----
Bulletin No. 76. Manganese and Chromium in California, by Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring. 1918, 248 pp., 51 illustrations, 5 maps, paper	$0.50
Bulletin No. 77. Catalogue of Publications of California State Mining Bureau, 1880–1917, by E. S. Boalich. 44 pp., paper	Free
Bulletin No. 78. Quicksilver Resources of California, with a Section on Metallurgy and Ore-Dressing, by Walter W. Bradley, 1919, 389 pp., 77 photographs and 42 plates (colored and line cuts), cloth	1.50
Bulletin No. 79. Magnesite in California, by Walter W. Bradley. 1925, 147 pp., 62 photographs, 11 line cuts and maps, cloth	1.00
†Bulletin No. 80. Tungsten, Molybdenum and Vanadium in California. (In preparation.)	
†Bulletin No. 81. Foothill Copper Belt of California. (In preparation.)	
**Bulletin No. 82. Second Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1916–1917, by R. P. McLaughlin. 1918, 412 pp., 31 illustrations, cloth	----
Bulletin No. 83. California Mineral Production for 1917, with County Maps, by Walter W. Bradley. 179 pp., paper	Free
**Bulletin No. 84. Third Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1917–1918, by R. P. McLaughlin. 1918, 617 pp., 28 illustrations, cloth	----
**Bulletin No. 85. Platinum and Allied Metals in California, by C. A. Logan, 1919. 10 photographs, 4 plates, 120 pp., paper	----
Bulletin No. 86. California Mineral Production for 1918, with County Maps, by Walter W. Bradley. 1919, 212 pp., paper	Free

† Not yet published.

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 87. Commercial Minerals of California, with notes on their uses, distribution, properties, ores, field tests, and preparation for market, by W. O. Castello. 1920, 124 pp., paper	----
Bulletin No. 88. California Mineral Production for 1919, with County Maps, by Walter W. Bradley. 1920, 204 pp., paper	Free
**Bulletin No. 89. Petroleum Resources of California, with Special Reference to Unproved Areas, by Lawrence Vander Leck. 1921, 12 figures, 6 photographs, 6 maps in pocket, 186 pp., cloth	----
Bulletin No. 90. California Mineral Production for 1920, with County Maps, by Walter W. Bradley. 1921, 218 pp., paper	Free
Bulletin No. 91. Minerals of California, by Arthur S. Eakle. 1923, 328 pp. cloth	$1.00
**Bulletin No. 92. Gold Placers of California, by Chas. S. Haley. 1923 167 pp., 36 photographs and 7 plates (colored and line cuts, also geologic map), cloth	----
Bulletin No. 93. California Mineral Production for 1922, by Walter W. Bradley. 1923, 188 pp., paper	Free
Bulletin No. 94. California Mineral Production for 1923, by Walter W. Bradley. 1924, 162 pp., paper	Free
Bulletin No. 95. Geology and Ore Deposits of the Randsburg Quadrangle, by Carlton D. Hulin. 1925, 152 pp., 49 photographs, 13 line cuts, 1 colored geologic map, cloth	2.00
**Bulletin No. 96. California Mineral Production for 1924, by Walter W. Bradley. 1925, 173 pp., paper	----
**Bulletin No. 97. California Mineral Production for 1925, by Walter W. Bradley. 1926, 172 pp., paper	----
Bulletin No. 98. American Mining Law, by A. H. Ricketts. 1931, 810 pp., 24 illus., flexible leather	2.00
Bulletin No. 99. Clay Resources and Ceramic Industry of California, by Waldemar Fenn Dietrich. 1928, 383 pp., 70 photos, 12 line cuts including maps, cloth	1.50
**Bulletin No. 100. California Mineral Production for 1926, by Walter W. Bradley. 1927, 174 pp., paper	----
**Bulletin No. 101. California Mineral Production for 1927, by Henry H. Symons. 1928, 311 pp., paper	----
Bulletin No. 102. California Mineral Production for 1928, by Henry H. Symons. 1929, 210 pp., paper	Free
Bulletin No. 103. California Mineral Production for 1929, by Henry H, Symons, 1930. 231 pp., paper	Free
Bulletin No. 104. Bibliography of the Geology and Mineral Resources of California, to the end of 1929, by Solon Shedd, 1931. (Preliminary Edition only, subject to revision)	----
Bulletin No. 105. California Mineral Production for 1930, by Henry H. Symons, 1931. 229 pp. paper	Free
Bulletin No. 106. Manner of Locating and Holding Mineral Claims in California (with forms), by A. H. Ricketts, 1931. 20 pp., paper	.25

PRELIMINARY REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**Preliminary Report No. 1. Notes on Damage by Water in California Oil Fields, December, 1913. By R. P. McLaughlin. 4 pp.	----
**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin. 4 pp.	----
Preliminary Report No. 3. Manganese and Chromium, 1917. By E. S. Boalich. 32 pp.	Free
**Preliminary Report No. 4. Tungsten, Molybdenum and Vanadium. By E. S. Boalich and W. O. Castello, 1918. 34 pp. Paper	----
**Preliminary Report No. 5. Antimony, Graphite, Nickel, Potash, Strontium and Tin. By E. S. Boalich and W. O. Castello, 1918. 44 pp. Paper.	----
Preliminary Report No. 6. A Review of Mining in California During 1919. By Fletcher Hamilton, 1920. 43 pp. Paper	Free
**Preliminary Report No. 7. The Clay Industry in California. By E. S. Boalich, W. O. Castello, E. Huguenin, C. A. Logan, and W. B. Tucker, 1920. 102 pp. 24 illustrations. Paper	----
**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----
**Catalogue of the Library of the California State Mining Bureau, September 1, 1892. 149 pp.	----
**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper.	----
Bulletin. Reconnaissance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper.	Free
Commercial Mineral Notes. A monthly mimeographed sheet, beginning April, 1923	Free

MAPS

Register of Mines With Maps.

Asterisks (**) indicate the publication is out of print.

	Price
**Register of Mines, with Map, Amador County	----
**Register of Mines, with Map, Butte County	----
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
**Register of Mines, with Map, Inyo County	----
**Register of Mines, with Map, Kern County	----
**Register of Mines, with Map, Lake County	----
**Register of Mines, with Map, Mariposa County	----
**Register of Mines, with Map, Nevada County	----
**Register of Mines, with Map, Placer County	----
**Register of Mines, with Map, Plumas County	----
**Register of Mines, with Map, San Bernardino County	----
**Register of Mines, with Map, San Diego County	----
Register of Mines, with Map, Santa Barbara County (1906)	$0.25
**Register of Mines, with Map, Shasta County	----
**Register of Mines, with Map, Sierra County	----
**Register of Mines, with Map, Siskiyou County	----
**Register of Mines, with Map, Trinity County	----
**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.25
Register of Oil Wells, with Map, Los Angeles City (1906)	.35

OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----
Geological Map of California, 1916. Scale 1 inch equals 12 miles. As accurate and up-to-date as available data will permit as regards topography and geography. Shows railroads, highways, post offices and other towns. First geological map that has been available since 1892, and shows geology of entire state as no other map does. Geological details lithographed in 23 colors. Unmounted	.75
Mounted	2.00
Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	.50

OIL FIELD MAPS

These maps are revised from time to time as development work advances and ownerships change.

	Price
Map No. 1—Sargent, Santa Clara County	$0.50
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	.75
Map No. 3—Santa Maria, including Casmalia and Lompoc	.75
Map No. 4—Whittier-Fullerton, including Olinda, Brea Canyon, Puente Hills, East Coyote and Richfield	.75
Map No. 5—Whittier-Fullerton, including Whittier, West Coyote and Montebello	.75
Map No. 6—Salt Lake, Los Angeles County	.75
Map No. 7—Sunset and San Emidio and Kern County	.75
Map No. 8—South Midway and Buena Vista Hills, Kern County	.75
Map No. 9—North Midway and McKittrick, Kern County	.75
Map No. 10—Belridge and McKittrick, Kern County	.75
Map No. 11—Lost Hills and North Belridge, Kern County	.75
Map No. 12—Devils Den, Kern County	.75
Map No. 13—Kern River, Kern County	.75
Map No. 14—Coalinga, Fresno County	1.00
Map No. 15—Elk Hills, Kern County	.75
Map No. 16—Ventura-Ojai, Ventura County	.75
Map No. 17—Santa Paula-Sespe Oil Fields, Ventura County	.75
Map No. 18—Piru-Simi-Newhall Oil Fields	.75
Map No. 19—Arroyo Grande, San Luis Obispo County	.75
Map No. 20—Long Beach Oil Field	1.25
Map No. 21—Portion of District 4, Showing Boundaries of Oil Fields, Kern and Kings counties	.75
Map No. 21A—Portion Kern and Kings counties	.75
Map No. 22—Portion of District 3, Showing Oil Fields, Santa Barbara County	.75
Map No. 23—Portion of District 2, Showing Boundaries of Oil Fields, Ventura County	.75
Map No. 24—Portion of District 1, Showing Boundaries of Oil Fields, Los Angeles and Orange counties	.75
Map No. 26—Huntington Beach Oil Field	.75
Map No. 27—Santa Fe Springs Oil Field	.75
Map No. 28—Torrance, Los Angeles County	.75
Map No. 29—Dominguez, Los Angeles County	.75
Map No. 30—Rosecrans, Los Angeles County	.75
Map No. 31—Inglewood, Los Angeles County	.75
Map No. 32—Seal Beach, Los Angeles and Orange counties	.75
Map No. 33—Rincon, Ventura County	.75
Map No. 34—Mt. Poso, Kern County	.75
Map No. 35—Round Mountain, Kern County	.75
Map No. 36—Kettleman Hills, Kings County	1.25
Map No. 37—Montebello, Los Angeles County	.75
Map No. 38—Whittier, Los Angeles County	.75
Map No. 39—West Coyote, Los Angeles and Orange counties	.75
Map No. 40—Elwood, Santa Barbara County	.75
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

o

94259 6-32 3M

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT ITS VARIOUS DEPARTMENTS MAINTAINED FOR THE PURPOSE OF FURTHERING THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

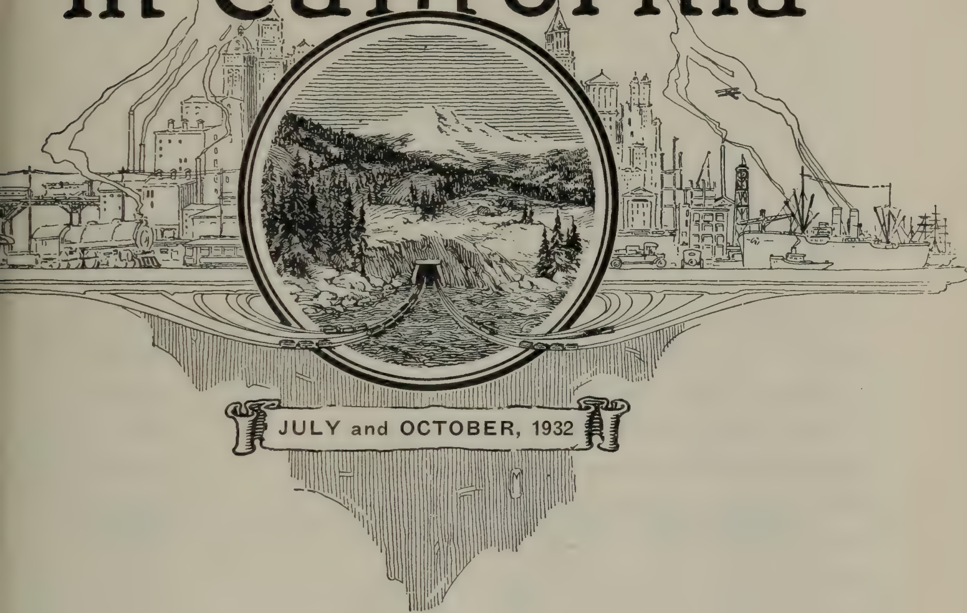
At the service of the public are the scientific reference library and reading room, the general information bureau, the laboratory for the free determination of mineral samples found in the State, and the largest museum of mineral specimens on the Pacific Coast. The time and attention of the State Mineralogist, as well as that of his technical staff, are also at your disposal.

Office hours: 9 a.m. to 5 p.m. daily.
Saturday, 9 a.m. to 12 m.

WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal. Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.

Mining in California



JULY and OCTOBER, 1932

PUBLISHED QUARTERLY

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES

FERRY BUILDING
SAN FRANCISCO

DIVISION OF MINES

EXECUTIVE AND TECHNICAL STAFF

WALTER W. BRADLEY
State Mineralogist

Olaf P. Jenkins, Chief Geologist - - - - - -	San Francisco
C. A. Logan, District Mining Engineer - - - - -	Sacramento
C. McK. Laizure, District Mining Engineer - - - -	San Francisco
W. Burling Tucker, District Mining Engineer - - - -	Los Angeles
Reid J. Sampson, Assistant District Engineer - - - -	Los Angeles
Chas. V. Averill, District Mining Engineer - - - -	Redding
Frank Sanborn, Mineral Technologist - - - - -	San Francisco
Henry H. Symons, Statistician and Curator - - - -	San Francisco
Herbert A. Franke, Junior Mining Engineer (Librarian) -	San Francisco

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
D. H. BLOOD, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 28 JULY AND OCTOBER, 1932 Nos. 3 and 4

CHAPTER OF

REPORT XXVIII OF THE STATE MINERALOGIST

COVERING

ACTIVITIES OF THE DIVISION OF MINES

INCLUDING THE

GEOLOGIC BRANCH

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1933

TABLE OF CONTENTS

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923.

Owing to a lack of funds for printing, this was changed to a quarterly publication, beginning in September, 1923. For the same reason the July and October, 1932, chapters have been combined, and beginning with the January, 1924, issue, it has been necessary to charge a subscription price of $1 per calendar year, payable in advance; single copies, 25 cents apiece. 'Mining in California' is sent without charge to our 'exchange list,' including schools and public libraries, as are also other publications of the Division of Mines.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

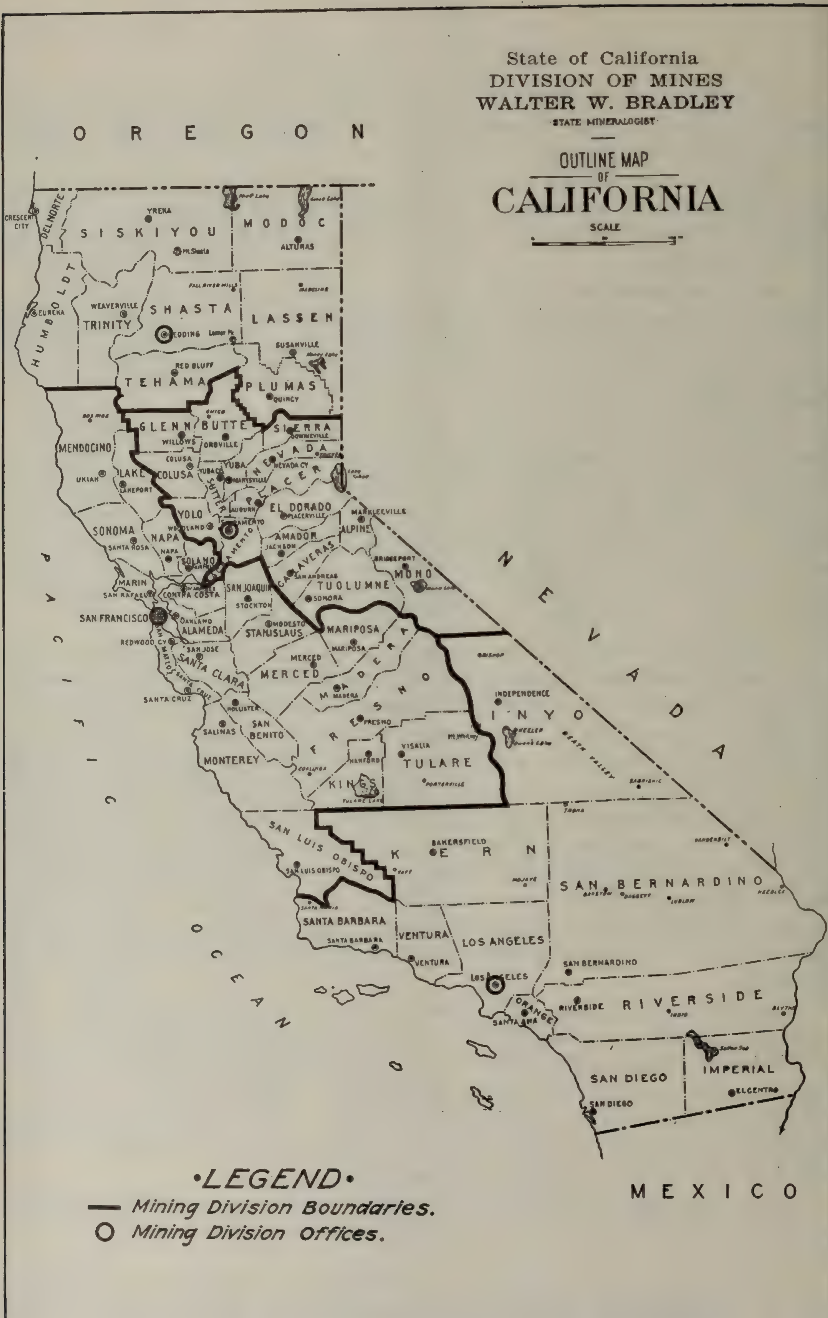
Such a publication admits of several improvements over the former method of procedure. Each issue contains a report of the current development and mining activities of the State, prepared by the district mining engineers. Special articles dealing with various phases of mining and allied subjects by members of the staff and other contributors are included. Mineral production reports formerly issued only as an annual statistical bulletin are published herein as soon as returns from producers are compiled. The executive activities, and those of the laboratory, museum, library, employment service and other features with which the public has had too little acquaintance also are reported.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued, as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.


State of California
DIVISION OF MINES
WALTER W. BRADLEY
STATE MINERALOGIST
OUTLINE MAP OF CALIFORNIA
SCALE
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
LAKE
COLUSA
YUBA
NEVADA
PLACER
SUTTER
YOLO
EL DORADO
ALPINE
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
MONO
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
CRESCENT CITY
YREKA
ALTURAS
EUREKA
WEAVERVILLE
REDDING
SUSANVILLE
RED BLUFF
QUINCY
WILLOWS
OROVILLE
DOWNIEVILLE
UKIAH
LAKEPORT
COLUSA
YUBA CY
MARYSVILLE
NEVADA CY
AUBURN
PLACERVILLE
MARKLEEVILLE
WOODLAND
SACRAMENTO
JACKSON
SANTA ROSA
NAPA
BRIDGEPORT
SAN ANDREAS
SAN RAFAEL
SONORA
STOCKTON
OAKLAND
MODESTO
REDWOOD CY
SAN JOSE
MARIPOSA
MERCED
MADERA
INDEPENDENCE
SANTA CRUZ
HOLLISTER
FRESNO
SALINAS
VISALIA
HANFORD
BAKERSFIELD
SAN LUIS OBISPO
MOJAVE
SANTA BARBARA
VENTURA
SAN BERNARDINO
LOS ANGELES
RIVERSIDE
SANTA ANA
SAN DIEGO
EL CENTRO
•LEGEND•
Mining Division Boundaries.
Mining Division Offices.

DISTRICT REPORTS OF MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions, and the locations of the branch offices, are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each division, prepared by the district engineer, will continue to appear under the proper field division heading.

Although the petroleum industry is but little affiliated with other branches of mining, oil and gas are among the most valuable mineral products of California, and a report by the State Oil and Gas Supervisor on the current development and general conditions in the State's oil fields is included under this heading.

County Reports.

The series of separate reports on the mines and mineral resources of the different counties, that together comprise the State Mineralogist's Reports XIV to XVII, inclusive, in the case of many of the counties have become exhausted. Beginning with the January, 1925, issue of 'Mining in California,' these have been revised and brought up to date, by presenting the district engineers' reports each in the form of a complete general report on the mines and mineral resources in one or more of the counties in each district.

This county series was completed during 1930. A new series of reports on individual economic minerals, mainly nonmetallics, was begun in 1931, and will be added to in future issues. Papers by the Geological Branch and other county reports are also included.

REDDING FIELD DIVISION

CHAS. V. AVERILL, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the Redding field division are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

SACRAMENTO FIELD DIVISION

C. A. Logan, Mining Engineer

Mr. C. A. Logan, District Mining Engineer, is engaged in preparing a special 'Mother Lode' Report, and there is no county report in this issue.

SAN FRANCISCO FIELD DIVISION

C. McK. Laizure, Mining Engineer

There is no report from the San Francisco Field Division, as the present series of county reports is complete for this district.

LOS ANGELES FIELD DIVISION

W. B. TUCKER and R. J. SAMPSON, Mining Engineers

VENTURA COUNTY

General Description.

Ventura County, created March 22, 1872, is one of the coast counties and lies between parallels 34° and 34° 50′ north latitude, having a coastline of about 50 miles. It is bounded on the north by Kern County, on the east by Los Angeles County, on the south by Los Angeles County and the Pacific Ocean, and on the west by Santa Barbara County. The total area is 1878 square miles. The population as shown by the census of 1930 was 54,477, and is now estimated at over 60,000.

The city of Ventura, originally called San Buenaventura, is the county seat, and is located on the shores of the Santa Barbara Channel. The cities of Oxnard, Santa Paula, and Fillmore are next in importance.

Ventura County is essentially an agricultural and stock-raising county: The increasing production of petroleum in the past few years, however, is rapidly bringing it forward on the list of mineral-producing counties.

Topography.

The northern portion of this county is characterized by the convergence of several important mountain ranges which make of it a high and rugged region. The more mountainous and rugged parts of Pine Mountain and Topatopa Mountain form what is considered one of the roughest and most inaccessible regions in California. Its lofty peaks range in elevation from 6000 to 9000 feet, the most prominent of which are Mount Pinos, elevation 8826 feet; Mount Frazier, 8026 feet; Pine Mountain, 7488 feet; and Alamo Mountain, 7371 feet. To the northwest extend the San Emigdio Mountains which form the connection between the Coast Range and the Sierra Nevada Mountains. To the west extend the San Rafael Mountains, while farther southward the Santa Ynez Mountains diverge from this group, running westward through Santa Barbara County.

The southern part of the county is characterized by a series of parallel folds, the axes of which lie east and west, forming low mountain ranges of no great continuity.

The principal valleys are Santa Clara, Ojai, Simi, and Las Posas.

The Santa Clara is a flat river wash, the level floor of which ranges in width from a mile at Piru to over five miles at Saticoy, where it

opens out into the wide Oxnard terrace. It is bounded on the north by Sulphur Mountain and the more rugged mountains to the east that form the divide between it and the San Joaquin Valley. On the south it is bounded by the Santa Susana, Oak Ridge, and South Mountains.

The Ojai Valley lies north of the Santa Clara Valley and is separated from it by Sulphur Mountain. A low ridge across its length divides the valley into two parts, called Upper Ojai Valley and Lower Ojai Valley. The lower valley is drained by San Antonio Creek, which flows westward into the Ventura River, while the upper valley is drained by Sisar Creek, a tributary of the Santa Clara River.

Simi Valley lies between the Oak Ridge Mountains on the north, and the Simi Hills on the south.

Las Posas Valley is a continuation of the same drainage basin, and westward joins the Santa Clara Valley, where it opens into the wide marine terrace.

Streams.

The two principal drainage systems of the county are the Santa Clara River and the Ventura River. Next in importance, but subordinate to these is Caleguas Creek, which drains the Simi and Las Posas Valleys.

The Santa Clara River rises in Los Angeles County and flows westward 75 miles, emptying into the ocean south of the city of Ventura. Its principal tributaries from east to west are the Castac, Piru, Sespe, and Santa Paula creeks, all of which flow from the north. This stream runs almost dry in the summer, but in the winter becomes flooded, often doing great damage in the valley.

The Ventura River receives its principal water supply from Matilija Creek, which rises on the southern slopes of Pine Mountain, and flows southward, entering the ocean at the city of Ventura. This river carries sufficient water throughout the year for irrigation purposes and to supply the city of Ventura.

Climate.

The climate in the southern portion of the county is delightful throughout the year, the summer heat being tempered by cool ocean breezes. Farther east in the valleys it becomes very hot during the dry season. The mountainous region in the northern portion of the county receives a coating of snow in the winter. The rainfall is confined to the winter and spring months.

Transportation.

The county is traversed by the Southern Pacific Railroad, with a branch line from Ventura to Ojai. At Montalvo, five miles east of Ventura, the main line divides into two branches, one going to Los Angeles via Las Posas and Simi valleys, the other through the Santa Clara Valley, joining the San Joaquin Valley line at Saugus.

With the exception of the higher mountainous areas, the county is easily accessible by roads, the main arteries being paved. Access to the gold and borax districts is obtained over the State Highway from Bakersfield to Los Angeles via Tejon Pass.

VENTURA COUNTY[1]

Year	Gold, value	Petroleum		Natural gas		Asphalt and bituminous brick		Brick	
		Barrels	Value	M. Cu. Ft.	Value	Tons	Value	M.	Value
1880	$354	(2)							
1881	600								
1882									
1883									
1884									
1885									
1886									
1887									
1888									
1889									
1890	2,468								
1891	1,715								
1892									
1893									
1894		290,913	$367,822			248	$4,800		
1895		244,624	244,624			175	3,500		
1896		248,000	272,800						
1897		368,282	368,282						
1898		427,000	571,000			4,105	80,775	286	$2,228
1899	3,990	496,200	496,200			5,188	103,760	375	3,000
1900	2,562	443,000	398,700			1,466	31,670	230	1,700
1901	4,183	472,057	236,028			2,073	30,945		
1902	2,012	475,000	455,000			37	370		
1903	1,087	542,902	517,611			1,114	13,368	1,380	12,900
1904	2,700	518,000	465,682	1,800	$2,700	3,169	38,028		
1905	1,200	375,522	236,578	3,831	5,000	3,000	30,000	1,300	10,400
1906	(3)	311,000	155,500	3,500	1,000	3,700	37,000	1,675	11,650
1907		352,224	211,334	1,825	2,278			1,600	12,800
1908		289,625	217,219	3,625	4,531			200	1,500
1909		344,419	223,872	1,721	2,151			1,275	7,625
1910		492,147	319,898	545	681			1,190	36,945
1911		499,082	349,777	[4]29,580	2,958			900	5,100
1912		662,300	584,811	[4]55,068	4,163			550	3,575
1913		899,007	907,997	62,200	6,220			1,023	6,085
1914		943,929	991,125	100,000	6,000			449	3,102
1915		1,017,220	869,723	491,879	29,670			200	2,500
1916		943,499	985,956	806,540	133,867			(3)	
1917		996,501	1,313,388	1,033,564	152,550			(3)	
1918		1,339,342	1,982,226	858,457	150,885				
1919		1,685,073	2,755,094	1,038,574	252,240			(3)	
1920		1,989,681	4,988,130	1,521,448	214,280				
1921		2,167,326	5,869,119	2,127,476	360,443			(3)	
1922		2,933,685	5,236,628	3,583,818	536,502				
1923		3,610,794	4,109,084	4,162,318	470,261				
1924		3,958,010	5,279,985	5,995,760	633,352				
1925		9,221,846	15,769,357	20,144,646	1,953,163				
1926		16,994,275	25,695,344	41,559,144	4,080,040				
1927		19,996,841	23,536,282	71,036,201	6,951,273				31,832
1928		22,143,318	24,311,149	67,058,513	6,196,549			(3)	
1929	473	24,003,969	27,602,164	77,293,145	5,812,729			(3)	
1930	221	19,983,341	27,896,744	54,741,670	3,749,829			(3)	
Totals	23,565	142,679,954	$186,752,933	353,716,848	$31,715,315	24,275	$374,216		$152,942

[1]Includes crushed rock, rubble, sand, gravel.

[2]Commercial production of petroleum in Ventura County began at least as early as 1874, in the Sulphur Mountain district, but detailed county segregations are not available for the early years.

[3]See under 'Unapportioned.'

[4]Quantity estimated, as only values given in reports of those years.

INERAL PRODUCTION, 1880-1930

Pottery clay		Sandstone		Miscellaneous stone,[1] value	Miscellaneous and unapportioned		
Tons	Value	Cubic feet	Value		Amount	Value	Substance
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	16,200	$16,500	-----	-----	-----	
-----	-----	33,200	20,000	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	-----	-----	
-----	-----	-----	-----	-----	250 tons	$6,500	Borax.
-----	-----	12,500	6,250	$35,279	-----	-----	
-----	-----	4,200	2,650	16,764	3,000 tons -----	60,000 4	Borax. Silver.
-----	-----	3,200	1,600	22,500	50 tons	2,500	Mica.
-----	-----	1,750	900	25,100	3,500 tons 50 tons	140,000 3,800	Borax. Mica.
-----	-----	6,000	3,500	31,227	50 tons	3,000	Mica.
30	$45	2,300	1,380	60,490	-----	-----	
-----	-----	1,320	792	-----	-----	-----	
-----	-----	-----	-----	20,880	-----	-----	
560	1,680	-----	-----	15,406	-----	-----	
-----	-----	-----	-----	144,226	-----	830,853	Unapportioned, 1900-1909.
-----	-----	900	450	35,000	-----	-----	
1,900	1,900	4,658	2,325	750	-----	-----	
1,000	1,000	4,600	1,850	-----	-----	-----	
3,000	2,990	300	150	-----	-----	1,530	Unapportioned.
-----	-----	1,195	502	-----	-----	-----	
-----	-----	-----	-----	2,674	-----	200	Other minerals.
(3)	-----	(3)	-----	14,200	-----	1,407	Brick, clay, sandstone.
(3)	-----	(3)	-----	30,000	-----	2,072	Brick and sandstone.
-----	-----	(3)	-----	52,900	-----	300	Other minerals.
(3)	-----	(3)	-----	5,000	-----	4,500 190	Clay and clay products. Other minerals.
(3)	-----	(3)	-----	25,265	-----	500	Mineral paint and sandstone.
-----	-----	-----	-----	11,250	-----	3,985 472	Clay and clay products. Mineral paint and sandstone.
-----	-----	-----	-----	62,888	-----	1,060	Mineral paint and sandstone.
-----	-----	-----	-----	88,211	-----	12,128	Mineral paint and sandstone.
-----	-----	(3)	-----	173,337	-----	2,720	Limestone.
-----	-----	-----	-----	131,200	-----	-----	
373,000	93,250	-----	-----	339,435	-----	300	Other minerals.
354,418	63,120	-----	-----	412,872	-----	-----	
238,914	238,910	-----	-----	332,195	-----	37,872	Brick, building tile and granite.
232,886	197,152	-----	-----	255,183	6 oz.	76,795 13,500 3 55,900	Brick and building tile. Granite (flagstone). Silver. Unapportioned.
(3)	-----	-----	-----	180,322	5 oz.	2 124,934	Silver. Brick, pottery clay, granite, limestone (shells).
205,708	$684,755	[3]92,323	$58,849	$2,525,374	-----	$1,387,027	

General Geology.

The rocks of the Ventura region fall into three classes: A metamorphic and granitic complex, which is commonly referred to as the 'basement complex,' a series of sedimentary rocks, and a series of igneous extrusive and intrusive rocks.

The metamorphic rocks are all of pre-Jurassic age and have been intruded by granite that is probably of the same age as that of the Sierra Nevadas, which is considered to be late Jurassic or early Cretaceous.

The sedimentary rocks, which in this region form the greater percentage, range in age from Upper Cretaceous to Recent.

The igneous rocks are practically all of the Miocene age and are mainly andesite, dacite, basalt, andesite breccia, and associated mud flows.

Mineral Resources.

Ventura County is the third county in the State in respect to the value of its mineral production for the year 1930, the exact figures being $31,952,052. The value of natural gas and petroleum amounted to $31,646,573; the remainder of the production amounting to $305,479 was from clay, crushed rock and gravel, mineral paint, and sandstone. The State Division of Mines records of mineral production of the county date from 1880. Considerable gold was produced in the county previous to 1880, but of this there is no record. The production of borax from the time of its discovery in this county in 1898 to 1907 amounted to over 35,000 tons, valued at over $1,000,000.[1]

Among its other mineral resources are: Asphalt, borax, clay, diatomaceous earth, gypsum, limestone, mineral water, mineral paint, molding sand, phosphates, and sandstone.

[1] Gale, H. S., Borate Deposits in Ventura County, Cal., U. S. Geol. Surv. Bull. 540, p. 434, 1912.

METALS

GOLD

The gold deposits of Ventura County are confined to the high mountainous region in the northeastern portion of the county embracing Mount Frazer on the north and McDonald Peak on the south, and known as the Piru District. The gold occurs in fissure veins in the mountains, which are composed largely of granite, syenite, schist, and slate, and in the gravels of the Piru drainage basin. It is said that the first gold discovered in California was that found in the placers of this district in 1841 by Andreas Castillero. In 1842 gold was shipped from the placers to the United States Mint at Philadelphia.[1]

The deposits of gravel extend along the north side of Piru River from about 2½ miles above the mouth of Lockwood Creek to its head, and also in San Quelmo Canyon, a tributary of Lockwood Creek. Sluicing and rocking have been carried on intermittently here for many years. The gold is coarse and not much worn. The gravels lie in the form of terraces, extending in places to the top of the hills between Piru River and Lockwood Creek. These gravels were probably deposited by a Pliocene river heading more toward Mount Pinos than the present Piru.

Underneath the gold-bearing gravels is an older deposit of a different character, and barren of gold. It is more firmly cemented and perhaps belongs to the Miocene, which is strongly developed in this section.

In a similar manner, gravels overlie the Tertiary on the flanks of Frazer Mountain and Mount Pinos. On the former mountain they are gold-bearing. In later years a number of attempts have been made to work the gravels and some production is reported to have been made. The principal mining development in recent years has been confined to the quartz veins in the Piru and Snowy Mining Districts.

This region suffered from the disadvantage of being over fifty miles from the main lines of transportation. The State Highway from Bakersfield to Los Angeles via Tejon Pass makes the district much more accessible; also the recent development of Lockwood Valley will insure better roads for automobile travel, and should greatly aid in its development.

Arrastra Flat Group of Claims. The group comprises two claims, Arrastra Flat and Max B., located in the Piru Mining District south of the Frazer Mine. The vein strikes northwest and southeast, and is probably on the same lode as the Frazer Mine. Workings consist of several tunnels and opencuts. D. W. Maxy of Gorman, owner.

Big Four Group of Claims comprises three claims; Big Four, Hornet, and Lookout, located in the Piru Mining District, on the southern slope of Frazer Mountain. F. W. Sprung of Ventura, owner.

[1] See Hittell's History of California, Vol. 11, p. 313.

Blue Bell Group of Claims. This group, comprising four claims known as Blue Bell, Red Bell, Silver Bell, and Yellow Bell, is located on Fitzgerald Mountain, 1½ miles southeast of Lockwood Valley, and one-half mile from Long Dove Creek. The course of the vein is north and south. The county rock is syenite and granite. Workings consist of tunnels and opencuts. Owners, C. H. Crandall and Dr. W. R. Colbert of Gorman.

Castac Mine is located on the ridge south of Piru River in the Snowy Mining District, about ten miles south of Gorman. Elevation is 4000 feet.

FIG. 1. Castac Mill on Piru Creek.

The property comprises three patented claims and two quartz claims held by location in Sec. 22, T. 7 N., R. 19 W., S. B. B. and M. Owners, Castac Mining Company; Chas. M. Dobson, president; A. B. Brant, secretary. Offices, 214 Citizens Bank Building, Pasadena, California. Under lease since 1927 to Padre Mining Co., Ltd., 1890 Crenshaw Boulevard, Los Angeles; Howard J. Hanna, president; G. L. Bergman, secretary-treasurer; W. P. Meacham, superintendent.

The outcrop of the Castac vein can be followed for over 10,000 feet on the surface. The vein has a general northwest strike, and dips

about 25° to the northeast. The width of the vein varies from two to four feet.

The country rock is granite and hornblende schist. The hanging wall of the vein is hornblende schist, and the footwall is granite and hornblende schist.

The main tunnel is 600 feet above the river and about 75 feet below the outcrop. The tunnel is driven S. 60° E. on the vein, a distance of 250 feet. Here the vein was cut off by a fault which strikes N. 50° E., and dips 60° NW. A drift was driven approximately 400 feet northeast on the fault, where the vein was encountered, and a drift run about 400 feet southeast on the vein. The vein has an average width of three feet. At 300 feet an ore shoot was encountered, which is said to have produced $35,000 in gold. It is said that 9000 tons of ore valued at $125,000 was milled from this level. Total amount of drifting and crosscutting on this level is 1000 feet. At 60 feet vertically below this tunnel is another tunnel with 1200 feet of underground workings. The ore developed is said to average $14.00 per ton. The quartz is free milling, with some iron pyrite.

An aerial tramway runs from the lower tunnel to the 5-stamp mill on Piru River. The mill was driven by water power. Idle.

Bibliography: State Mineralogist Reports VIII, p. 683; XII, p. 315; XIII, p. 497; XV, pp. 759–760; XXI, p. 230.

Contact Mine comprises three claims located on Fitzgerald Mountain, in Secs. 34 and 35, T. 8 N., R. 20 W., S. B. B. and M., six miles southwest of Stauffer. Elevation 6000 feet. Owners, Thomas and Richard Harris of Ventura.

The vein strikes north and dips 40° west, varying in width from a few inches to four feet. It is said to average 14 inches. It has syenite for a footwall, with a porphyry hanging wall.

The workings consist of three tunnels driven along the vein at different levels and connected by winzes. The main working tunnel is 1000 feet in length. The greatest vertical depth of the vein exposed below the outcrop is 700 feet. The property is being developed by the owners during the summer months.

Bibliography: State Mineralogist's Report XV, p. 760; XXI, p. 230.

Esperanza (Foley) Mine is on the western slope of Frazer Mountain, at an elevation of 7000 feet. Holdings comprise three claims. Owners, Chas. Seifert and Mrs. Bessie Sibert of Los Angeles. Under option to P. J. McLaughlin of Los Angeles.

Three parallel veins varying in width from a few inches to four feet occur in the granite. These strike N. 30° E., and dip 65° E. Workings consist of three shafts about 75 feet deep sunk on the different veins, and a tunnel 125 feet in length, which is being driven to connect with one of the shafts. The ore is free milling quartz with some pyrite and chalcopyrite. Equipment consists of a Western Engineering Company's mill. Three men are employed.

Bibliography: State Mineralogist's Reports VIII, p. 682; XIII, p. 497; XV, p. 760.

2—97834

Frazer Mine, located in 1867, was the first quartz mine worked in the Piru District. The property comprises two claims known as Frazer No. 1 and Frazer No. 2, and is located in Sec. 13, T. 8 N., R. 20 W., S. B. B. and M., on the southern slope of Frazer Mountain, at an elevation of 6500 feet. Owner, Miss Nannie Bicknell. D. S. DeVan, agent, 530 W. 6th St., Los Angeles.

The vein strikes northwest and is nearly vertical. The country rock is porphyry, gneiss, and talcose slate. The vein quartz is free milling, and contains a percentage of pyrite and chalcopyrite. The average value of the ore is said to have been from $15.00 to $18.00 per ton in gold.

Workings consist of seven tunnels driven on the vein at different elevations. These tunnels are from 40 to 500 feet in length. Total amount of underground workings is over 3000 feet.

In 1893 the mine was sold to the Frazer Mining Company of Los Angeles and operated until 1895, when operations were suspended, and have not since been resumed. This mine has been the largest producer in Ventura County. Reported production, $1,000,000.

Bibliography: State Mineralogist Reports VIII, p. 682; XII, p. 315; XIII, p. 497; XV, p. 760.

Golden Bloom Group of Claims comprises three claims known as Golden Bloom, Lead Bloom, Crooked S., located in Piru District on Fitzgerald Mountain, about one mile south of the Contact Mine. Workings consist of short tunnels and opencuts. Owner, R. H. Colbert of Gorman.

Juanita Group, comprising 8 claims, is in Gold Canyon about 2 miles north and slightly west of the Castac Mine. Elevation approximately 4300 feet. Owners, W. P. Meacham, Gorman, California, and G. L. Bergman, Los Angeles.

On these claims it is reported that a vein which strikes NW.-SE. and dips about 40° to the northeast, occurs in the granitic country rock of the district. The vein up to 6 feet in width has been exposed by opencuts and short tunnels, one of which is 125 feet in length. It is also stated that average samples from six of these opencuts showed values of $18 a ton.

Idle except for assessment work.

Oro Fino Mine comprises two claims known as Oro Fino and Golden Era, located in the Piru Mining District south of Frazer mine. The vein strikes northwest and southeast. The average width is six inches. The country rock is granite. Workings consist of a shaft and short tunnels. Idle. Owners, A. F. Maxy and Chas. Maxy of Gorman.

Patton Mine is located in San Emigdio in the Piru Mining District. Workings are superficial. Owners, L. M. Patton, A. C. Patton, and Harvey Simpson of Ventura.

Red Rock Group of Claims comprises two claims known as Red Rock and Oak, which adjoin the Castac mine on the southeast. The claims are located in Sec. 22, T. 7 N., R. 19 W., S. B. B. and M., on the ridge between Piru River and Snowy Creek, eight miles south of Gorman. Elevation 4500 feet. Owner, William Snyder of Gorman.

The vein, which has an average width of three feet, is a continuation of the Castac vein. It strikes northwest, and dips 45° northeast. Samples taken from different points along the outcrop are stated to have averaged $15 in gold. The country rock is schist.

Workings consist of a tunnel driven southeast 125 feet in the hanging wall of the vein, and a number of opencuts along the vein. One man is employed.

White Mule Group of Mines is on the western slope of Frazer Mountain, at an elevation of 6000 feet. The property includes the *Bunker Hill* and *Fair View* mines. Owner, Fred M. Wilcox, 328 O. T. Johnson Building, Los Angeles.

The vein strikes east and has a dip of 45° to the north. The average width of the vein is three feet. The quartz is heavily mineralized with pyrite, marcasite, and chalcopyrite.

On the White Mule Claim is an incline shaft 320 feet on the vein, and in a gulch south of this shaft, a crosscut tunnel has been driven 300 feet N. 20° E. with the intention of intersecting the shaft to drain the mine workings. The vein in the Bunker Hill claim was developed by tunnels and opencuts, most of which are caved.

Equipment consists of a gasoline hoist, pumps, and a blacksmith shop. Idle.

Bibliography: State Mineralogist's Reports VIII, p. 682; XII, p. 316; XIII, p. 497; XV, p. 760; XXI, p. 232.

MOLYBDENITE

Small kidney-like deposits of molybdenite associated with copper ores occur on Frazer Mountain and on McDonald Peak. James McDonald of Ventura has done some development work on a deposit located near the headwaters of Alder Creek, in the Snowy Mining District. Five claims have been located in Secs. 11 and 12, T. 6. N., R. 19 W. The country rock is granite.

NICKEL AND COPPER

Ventura Mine. This property, consisting of 480 acres, is a part of El Conejo Rancho and is located at the foot of the south slope of Simi Peak on the edge of Russell Valley, about 3 miles northeast of Triunfo, in T. 1 N., R. 18 W., S. B. B. and M., and about 40 miles northwest of Los Angeles. Elevation 1350 feet. Owner, Mrs. E. W. Gard and sister, Los Angeles. Under lease to T. Rosenberger, 851½ Crenshaw Boulevard, Los Angeles.

Simi Peak consists largely of sandstone with some interbedded shales. At its base there has been an intrusion of gabbro. This dike has a general E.-W. strike and dips 20° to the north. It is traceable by means of occasional exposures for some four or five miles west and an unknown distance east of this property. Its width is not fully determined but appears to vary from about 300 to 600 feet. Both hanging and footwall of this dike are sandstone. The contact on the footwall is marked by a heavy gouge which, in one place, is more than 20 feet wide. The dike which has been exposed on this property for a width of about 250 feet shows mineralization across this entire width

and indications are that it may be more than 500 feet wide in places. The sandstone at the contact is also mineralized. Mineralization in the sandstone consists of cuprite, azurite and malachite, together with some nickeliferous minerals which were not identified, while minerals in the dike rock are apparently all sulphides, consisting of the following: Millerite (nickel sulphide), pentlandite (sulphide of iron and nickel), pyrrhotite (nickeliferous in part) and some chalcopyrite.

The zone in which this mineralization is known to occur has been proved on surface for a length of approximately 800 feet. From samples in present workings it is estimated that the nickel content averages something over 1%, with a small amount of copper and gold.

A tunnel has been driven N. 76° E. a distance of 200 feet. This tunnel is in the central portion of the dike and preparations are being made to crosscut to both foot and hanging wall at its face. Values in tunnel were reported as follows:

First 50′	1.75% nickel
50–75′	1.23% nickel
75–100′	1.28% nickel
100–125′	1.50% nickel
125–150′	1.25% nickel
150–175′	1.00% nickel
175–200′	0.29% nickel

Some fifty feet west of the portal of this tunnel a shaft has been sunk 100 feet on the footwall side. At the 50-foot level a crosscut was driven north a distance of 90 feet. It is reported that the crosscut showed an average nickel content of 1.6%; also that the first eleven feet on footwall side showed 2½% copper, 3% nickel and $2.50 in gold. This eleven feet was probably in the sandstone. Contact marked by two feet of gouge and remainder of crosscut in the dike which here may have a width of about 300 feet. At the time of visit the shaft was filled with water. About three hundred feet west of the shaft the dike has been trenched across a width of 175 feet, with average values reported as 1% nickel. Sixty feet under the trench and parallel to it, a crosscut tunnel has been driven north 165 feet. The first 65 feet was in the unaltered sandstone, then 27 feet of black clay gouge, only slightly mineralized, 40 feet of well-mineralized dike rock; the last 35 feet and the face show highly mineralized material. It is reported that magnetometer readings indicate that the next 75 feet in this crosscut will continue to show ore.

It is planned to sink the shaft to 250 feet and crosscut the dike. Electric power has been brought from a line about one mile away.

Two hundred cubic foot compressor, hoists and sinking pumps are installed.

Eight men are now employed.

PLATINUM

Platinum is said to occur in the black sands of Lockwood Creek, but it is probably not present in commercial quantity.

NONMETALLIC MINERALS

ASPHALT AND BITUMINOUS ROCK

Extensive deposits of natural asphalt and bituminous rock are located in Brea Canyon, Cañon Del Diablo, Upper Ojai Valley, and Punta Gorda. The manufacture of asphalt by refining from crude petroleum has entirely replaced its production from the natural asphalt and bituminous rock deposits, and no work has been done on the various deposits for years.

Brea Canyon Mine is on the Cañada Larga Ranch, five miles north of Ventura. W. R. Welden of Ventura, owner. Narrow veins of bituminous rock are irregularly distributed over an area of 200 acres.

Bibliography: State Mineralogists's Reports XIII, p. 44; XV, p. 754; XXI, p. 232. Bull. No. 11, p. 48.

Cañon Del Diablo Mine is five miles northwest of Ventura on the Cañada de San Miguelito Ranch. The Taylor Estate, Ventura, owner. A detailed report of this mine is given by Prof. E. W. Hilgard in the Tenth Annual Report of the State Mineralogist.

Bibliography: State Mineralogist's Reports X, p. 763; XIII, p. 44; XV, p. 754; XXI, p. 233.

Ojai Mine is in Secs. 3 and 10, T. 4 N., R. 22 W., S. B. B. and M., three miles west of Ojai in the Upper Ojai Valley. It is a deposit of decomposed sandstone and shales impregnated with heavy viscous bitumen which is seeping out of the bituminous shales. Undeveloped. Owners, J. S. Briggs and F. W. Ewing of Ventura.

Bibliography: State Mineralogist's Reports XIII, p. 45; XV, p. 754; XXI, p. 233. U. S. Geol. Surv., Twenty-second Annual Report, Part I, p. 446.

Punta Gorda Mine, one-fourth mile north of the Southern Pacific Railroad at Punta Gorda, is in Sec. 1, T. 4 N. R. 25 W., S. B. B. and M. Asphaltum occurs in irregular veins in bituminous shales and clays which strike east, dipping steeply to the north. Owners, Henry D. Abbott and Thomas Gaynor of Punta Gorda.

Bibliography: State Mineralogist's Reports XII, p. 33; XIII, p. 45; XXI, p. 233. U. S. Geol. Surv., Twenty-second Annual Report, Part I, pp. 445–446.

Rincon Mine, one and one-half miles northeast of Punta Gorda, is a small deposit of bituminous sand. The mine has not been worked to any extent.

Bibliography: State Mineralogist's Reports XII, p. 33; XIII, p. 45; XV, p. 754; XXI, p. 233.

BORAX

Colemanite, a borate of lime, was first found in Ventura County in 1898. The deposits are confined to a narrow belt along the eastern slope of Mount Pinos, in the extreme northeast corner of the county,

and are classed among the few important borax deposits of the United States.

Three important mines have been developed in the district, and a considerable number of other holdings have been worked. These mines lie in the foothills, at the northern margin of Lockwood Valley, at the headwaters of Piru Creek. They are known as Columbus, Russell, and Frazier Mines. The mines are at present inactive, mainly on account of their distance from railroad transportation, and the development by the Pacific Coast Borax Company of large deposits near Kramer, Kern County, which are more favorably situated in this respect.

The colemanite deposits occur within a series of bedded rock formations that have been extensively folded and faulted. In general, the trend of the outcrop is northeast, and the beds dip southeastward, away from the higher elevations in the Mount Pinos Range. The ore has not been found to any extent in outcrops on the surface.

Quoting Mr. Hoyt S. Gale, who made a detailed report on these deposits in Bulletin 540, U. S. Geol. Surv.:

"The borate-bearing beds lie in the sedimentary rocks closely associated with the basalt lava flows * * *

"Massive ledges of limestone occur within these shale zones, particularly at the Frazier, Russell, and Columbus properties, and appear to be intimately associated with the principal ore bodies. * * *

"The colemanite of the deposits of Ventura County occurs in roughly lenticular bodies which are extremely irregular in outline. The greater part of the ore is massive and crystalline ranging from the transparent glassy crystals occurring here and there to milky-white masses. Most of the deposits are dark-gray to blackish color, probably owing to included impurities. In general the material would be described as a gray ore * * *

"The gangue of the colemanite ore in Ventura County is chiefly shale with some limestone. The limestone is believed to be directly associated with the larger ore bodies. * * *

"The outcrop of the colemanite ore-bearing zones may be distinctly traced at least for a certain distance at the Frazier, Russell, and Columbus mines, and as these are the only occurrences of proved ore in depth * * *

"The chief characteristics of the outcrops seem to be the occurrence of gypsum, in stringer form, mainly interlaminated in the bedding of the fissile and crumbled shales, as a rule closely associated with beds of basaltic lava and in the principal ore bodies with ledges of massive travertine-like limestone. A characteristic of the associated shales that is conspicuous in some of the outcrops is the occurrence of small rounded calcareous concretions or 'buttons' * * *"

Columbus Mine comprises one patented claim of 160 acres, and ten unpatented claims located in Sec. 14, T. 8 N., R. 21 W., S. B. B. and M. The mine is the most northeasterly of the three developed mines of this district. The property was located in 1899 and operated continuously from 1902 to 1907. Sold to the National Borax Company in 1912.

This company erected bins and a sorting plant; also a rotary roaster six feet in diameter by sixty feet in length, jaw crusher, and screens were installed. Crude oil was used as fuel. Shut down in 1913 and has since been idle. Owner, United States Borax Company of West Virginia; C. B. Zabriske, president.

Workings consist of a vertical shaft and numerous tunnels, all of which are caved.

The orebody is associated with massive limestone which outcrops in the gulch just above the mine. This ledge strikes northeast and stands nearly vertical. Production from this property began in 1902, and it is reported to have produced 9000 tons of crude ore up to 1907, after which the property was shut down. Practically all equipment has been junked and is being sold. Only assessment work is being done on the unpatented claims.

Bibliography: U. S. Geol. Surv. Bull. 540, p. 448.

Frazier Mine is situated about midway between Seymour and Bitter creeks, being located southwest of the Russell Mine. It comprises twenty patented claims. Owned by the United States Borax Company; C. B. Zabriskie, president.

This mine was the first property located for borax in the district and has the most extensive underground development. The first locations were filed in 1898, and the work developed was undertaken soon afterwards. The mine first reported production in 1899, and was a producer until 1907, when operations were suspended. It is estimated that the total amount of crude ore shipped from this property has been about 25,000 tons.

The main workings are confined to Sec. 14, T. 8 N., R. 21 W., S. B. B. and M. The orebody was worked by a number of tunnels, the main one being 1700 feet long. These are driven along the course of the vein. The outcrop of the ore-bearing zone is repre-

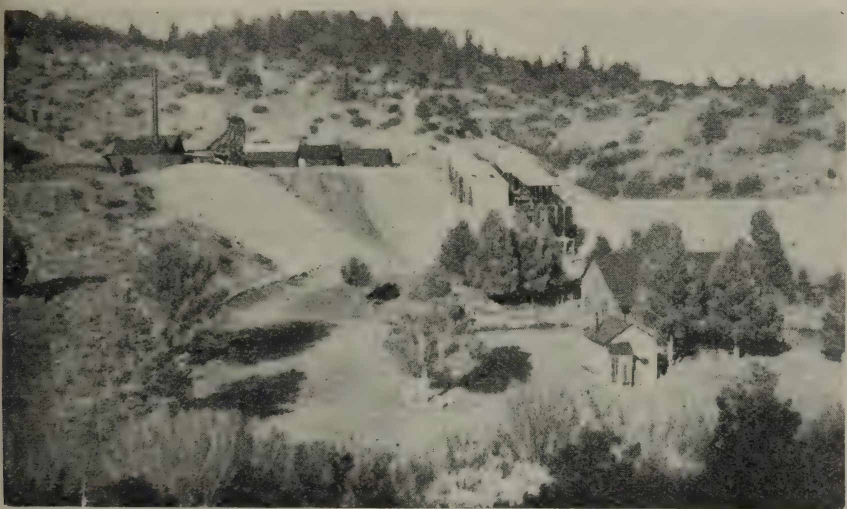


Fig. 2. Russell Borate Mine. Stauffer, Ventura County.

sented by a thickness of 40 feet or more of thin bedded gypsiferous shale, which includes a ledge of fractured limestone some 12 feet thick. The orebodies are lenticular, often averaging 14 feet in width. The ore consists chiefly of whitish or grayish crystalline material which is a massive colemanite. All equipment on the property has been dismantled and sold.

Bibliography: U. S. Geol. Surv. Bull. 540, p. 443.

Russell Mine lies between the Columbus and Frazier Mines, in Seymour Canyon, and comprises 200 acres near the middle of Sec. 14, T. 8 N., R. 21 W., S. B. B. and M. Owned by the Russell Borate Mining Company, 624 California Street, San Francisco.

The workings consist of the main shaft 200 feet deep, with levels at 50′, 100′, and 200′. The 200-foot level is the main working level. It is 450 feet long running N. 16° W., and strikes the orebody at 319 feet. The ore developed on this level strikes N. 75° W., and dips

60° S. It has been developed on three sides by drifts. A winze was sunk from the 200-foot level and is said to be in ore to a depth of 50 feet.

The orebody in the mine is included in a section of shale and limestone interbedded in the basaltic flow rocks, the whole series having about a dip of 60° S. The orebodies are very irregularly distributed in the ore-bearing zone. The ore consists of glassy crystalline colemanite, mostly massive, varying from white to black in color, and is so mingled with limestone that it varies from nearly pure colemanite to limestone masses containing blotches of colemanite.

Equipment consists of 25-ton borax drying furnace, sorting bins, compressor, blacksmith shop, store, and other buildings. This is the only mine at which the equipment is kept in good condition. Idle.

Bibliography: U. S. Geol. Surv. Bull. 540, p. 445.

Other Deposits and Prospects: Considerable prospecting has been done, and a great many claims have been located along the gypsiferous shales interstratified with basaltic lava flows that are exposed in the lower part of the canyon of Bitter Creek, west of the Frazier mine. It is reported that some ore was mined and shipped from this area. All workings are caved.

The borate-bearing beds which are exposed on the south side of Cuddy Canyon, at the foot of Frazer Mountain in Secs. 34 and 35, T. 9 N., R. 20 W., in Kern County, extend southwestward through Seymour Creek, Bitter Creek, and west of the North Fork of Lockwood Creek. A large number of locations have been made along this belt, and considerable prospecting has been done.

The shales are again exposed in the Upper Valley of Seymour Creek above Russell mine. A considerable amount of development work has been done in this area, but no ore developed.

In the past a number of prospect tunnels were driven along an outcrop of the gypsiferous shales on the Middle Fork of Lockwood Creek, and it is stated that several cars of colemanite were shipped from this point.

Some prospecting has been done for borate ores on the canyon of the North Fork of Lockwood Creek. It is stated that 160 tons of ore were shipped from a deposit on the west side of the creek. The prospects along this creek are in gypsiferous shales underlying the lava flows. These shales and lava flows outcrop westward from the North Fork for a considerable distance, probably as far as Dry Canyon.

CLAYS

The clay deposits of Ventura County are mostly low-grade clays which include the adobe clays, common red brick and tile clays, and shales. The adobe clays are extremely strong plastic clays that slake readily when wet to a very sticky, pasty mass, and become hard on drying. A supply of fairly good clay and gray and blue shale is found at a number of points in Ventura County.

A low rounded hill located northwest of Montalvo Station, and west of the Los Angeles-Ventura Highway, contains beds of red vitrified clay. This clay is suitable for the manufacture of vitrified brick.

On the southwestern slope of Sulphur Mountain, west of Santa Paula Creek are beds of blue and gray plastic shale with an overburden of adobe that is suitable for the manufacture of common red brick and building tile. These deposits are being developed three miles north of the city of Santa Paula, on the Santa Paula-Ojai road.

Extensive beds of yellow and blue plastic shale are found in the hills east of the Ventura River, about two miles north of the city of Ventura. These beds of shale have been proved by drilling and excavating operations that show they extend north of the city limits of Ventura to Cañada de San Joaquin. Where these deposits are being developed the hill rises above the floor of the valley to an elevation of 500 feet. The clays are suitable for the manufacture of common red brick, roofing, building and drain tile.

An extensive belt of diatomaceous shale, which has a general strike to the northwest, is exposed on the Ventura-Ojai road between Cañada Larga Canyon and San Antonio Creek. These deposits may prove of commercial importance for the manufacture of light insulating brick.

Deposits of *montmorillonite* occur in a belt of diatomaceous shales on the Ventura-Ojai road five to nine miles north of Ventura. Montmorillonite is a clay-like variety of kaolin, containing a great amount of combined water. It is a form of halloysite, hydrous silicate of alumina. The material is quite soft, is white, gray, and red, has a soapy feel, and disintegrates when exposed to air. It is of commercial value for cleaning compound, softening of water, as a paint filler, and is used in the oil refineries as a purifier of oils.

Associated Oil Company clay pit is about 2 miles north of the city of Ventura, and 2 miles east of Ventura Avenue on the very top of a north-south range of hills. It is reached by six miles of good road from Ventura Avenue.

The deposit has been opened on the top of the hill where apparently most of the desirable material, a dark gray, plastic clay, has been removed, it being reported that the other strata contain too much sand for their purpose.

The top of this hill has been removed to a maximum depth of about thirty feet, leaving it level and roughly circular, having a diameter of about three hundred feet. The shovel has been moved down onto the road where it excavates a light brown, thinly-bedded, soft shale which is apparently quite free from grit.

This material is dumped onto the hillside at the top of the mixing plant where it is held by board walls some three to four feet high. From this bin it is sluiced into a mixer by water pumped up from oil-well mud catch basins. The mixer is made from an old boiler shell and is similar to a log washer in its action. From the mixer material goes to two circular steel tanks, 30 feet in diameter by 24 feet high, then to 3 Ideal mud pumps which distribute it through 6-inch pipe to the various wells, the most remote of which is 3 miles distant. Capacity is 15,000 barrels of mud daily which weighs from 75 to 85 pounds per cubic foot.

Eighteen men are employed when plant is operating at capacity. It is now used only as an emergency plant as the company's present requirements are being met by the product of a mud reclaiming plant.

Connett Pit is 4 miles north of the town of Ventura on Ventura Avenue. This ground is under lease to *Lang Transportation Company*, 5501 Santa Fe Avenue, Los Angeles. Owner, Connett, of Ventura.

The present pit, 100 feet long by 50 feet wide, with a 40-foot face, is on the west slope of a hill whose axis lies in a NW.-SE. direction. The clay, which is a gray, somewhat plastic material, is used for rotary mud in oil wells. It is loaded into trucks by a power shovel having a ⅞-cubic yard dipper and delivered to the various wells. Apparently there is a large tonnage of this clay in the hill which rises some 150 to 200 feet above the valley floor.

Four to 6 men employed at present.

BRICK AND TILE

Only two producers of brick and tile are operating in the county.

Anderson & Hardison Pressed Brick Company; J. C. Hardison, president; G. A. Anderson, secretary, Santa Paula. The plant is three miles north of Santa Paula, on the Santa Paula-Ojai road. The clay used is a gray plastic shale, which is hauled from a hill west of Santa Paula Creek by a Fordson tractor and scraper.

The material from the storage hopper is elevated by a bucket-elevator to a pulverizer, and is then passed over a 12-mesh incline screen. The minus 12-mesh material goes to the mixer; the oversize is returned to the pulverizer. From the mixer the material goes to a Berg Brick Press. From the press the bricks are loaded on hand trucks and transported to the yard, where they are burned in open kilns. Natural gas is used for fuel. The capacity of the plant is 15,000 brick per day. Ten men are employed.

Peoples Lumber Company, Ventura, C. D. Bonstell, manager, has a brick and tile plant one mile north of Ventura. The deposit being worked is a yellow and blue plastic shale, and is located in the hills east of the Ventura River. Trucks deliver this clay from the clay bank where it is loaded by means of steam shovels and hauled a short distance, then dumped through a chute into a storage bin. The material from the bins is conveyed to a Potts disintegrator and rolls. From the rolls the ground product is elevated by bucket elevator to a piano wire screen. Through-size goes to a storage bin, oversize being returned to the rolls. From the bin the material is fed by automatic feeder to the pug-mill, and then it goes to the clay auger machine. From the clay auger machine the material passes to a revolving wire-cutting machine. Brick and tile is then transported to drying sheds, where they are dried by hot air.

The plant has a capacity of 20,000 brick and 25,000 tile per day. The brick and tile are burned in open kilns. Natural gas is used as fuel. The company manufactures common red brick, building and drain tile, and roofing tile. When operating to capacity fifteen men are employed.

Shell Oil Company clay deposit is on the west slope of a range of hills just east of the city of Ventura. The property is about 1½ miles north of Ventura. It is under lease to the Shell Oil Company.

The deposit consists of a series of beds of plastic clay and fine-grained, soft, loosely coherent shales, whose bedding planes are from 6 to 12 inches apart. The color varies from a dark gray to light brown. It may contain a considerable percentage of very finely divided quartz but no grit is to be detected by rubbing in the hands. The strike of the deposit is parallel to the axis of the hills, N.-S., and the dip about 35° to the west.

An extensive pit has been made about one-quarter of a mile north of the mixing plant. This pit consists of 3 benches, each about 1000 feet long by 30 to forty feet high, the total height being about 250 feet.

Material is loaded into trucks by gas-engine shovels and hauled to the plant which is approximately on the same level as the floor of the lower bench of the quarry. Trucks discharge into a bin; thence by apron feeder to 36-inch by 48-inch rolls, to incline conveyor and circular steel bin. The maximum size in this bin is about 1 inch. From this bin it is discharged through a rack and pinion gate to a steel trough, where water is added; thence to a log washer which breaks up the lumps, discharge is through screens with $\frac{1}{8}$-inch circular openings, to 4 steel tanks, about 24 feet in diameter by 12 feet high. From these tanks material goes to 2 Wilfley centrifugal sand pumps and 2 Gardner Booster pumps, piston type. The plant is electrically driven, each machine having individual motor drive.

Idle at time of visit.

DIATOMACEOUS EARTH

South Mountain Deposit. Thinly laminated beds of yellowish white diatomaceous earth outcrop along the south slope of the mountain at an elevation of 2000 feet. These beds strike east and dip 60° N. Six placer mine locations consisting of 560 acres have been made along the exposures which are located in Secs. 19 and 20, T. 3 N., R. 20 W., and Sec. 24, T. 3 N., R. 21 W. Joshua Stockton of Santa Paula is the owner.

These exposures are prominent and outcrop boldly for over two miles; and the beds have a probable thickness of 1000 feet. The owner has made a large number of opencuts along the outcrops, a number of trails have been built and a road has been built up the south side of the mountain to the top, which also exposed the material. This material is white, gray, and yellow in color, and if closer to railroad transportation, would be of commercial importance.

GYPSUM

Deposits of gypsum occur interbedded with diatomaceous shales on the low divide between Upper and Lower Ojai Valleys, on South Mountain and Oak Ridge. Owing to the association of the gypsum with clay and other impurities, the deposits have not been worked in recent years.

Ojai Gypsum Mine is three miles east of Ojai on a low divide that separates the two Ojai valleys. The deposit was worked in 1890 by the Tacoma Calcium Company, which sank a shaft and did considerable drifting. The gypsum developed in the workings is said to have con-

tained numerous small stringers of black clay. This made hand sorting necessary, and the property was abandoned. Workings caved.

Bibliography: State Mineralogist's Reports VIII, p. 688; Bull. 38, p. 288. U. S. Geol. Surv. Bull. 223, p. 122.

South Mountain Deposit, owner, Joshua Stockton, Santa Paula. The deposit is located on the south slope of South Mountain at an elevation of 2000 feet, about four miles south of Santa Paula. The gypsum occurs interbedded with the diatomaceous shales, is soft and white, and massive but granular in texture. Undeveloped.

Sunset Plaster and Cement Company, Fillmore, worked a deposit of gypsum in Secs. 12 and 13, T. 3 N., R. 20 W., S. B. B. and M., four miles by road south of Fillmore. The gypsum occurs interbedded with diatomaceous shales which strike east and west with a flat dip to the north. The gypsum is white and massive.

This deposit is reported to have produced 10,000 tons, and was operated from 1911 to 1915. Idle.

LIMESTONE

The only known deposits of limestone of commercial importance are beds outcropping in Matilija Canyon. The most prominent beds occur associated with clay and lime shales, southwest of Matilija Creek, and have a general east and west strike. This belt of limestone is two miles north of Matilija Springs, and the outcrops are exposed for a distance of several miles. North of Lyons Springs, on the north side of the canyon is another prominent outcrop of limestone, which can be traced for several thousand feet. This material is said to be a natural rock cement.

Argilla Group of Claims is located in Secs. 23 and 24, T. 5 N., R. 24 W., S. B. B. and M., nine miles northeast of Ojai. Owner, E. Duryea, Hollingsworth Bldg., Los Angeles.

A massive bed of limestone striking east, and dipping south, is exposed on the south side of the canyon. This deposit has been recently sampled and the rock is said to be excellent natural cement. An analysis of an average sample as given by E. Duryea is as follows:

Silica	16.015%
Aluminum and Iron Oxide	5.320%
Lime	42.630%
Magnesia	1.119%
Carbon dioxide	34.190%

A good wagon road goes as far as Lyons Springs, and a good trail for the remaining distance.

Matilija Group of Claims comprises two claims located in Sec. 19, T. 5 N., R. 23 W., eight miles north of Ojai. Owner, Joshua T. Stockton and J. A. Barry of Santa Paula.

Beds of hard blue limestone are exposed along the top of the ridge north of Matilija Canyon, about one-half mile north of Lyons Springs. The outcrop of blue limestone strikes east and west, and is 75 to 100 feet in thickness. This outcrop is exposed for a distance of about one-half mile. In a side canyon below the outcrop are exposures

of lime shale. The rock is said to be an excellent natural cement. Undeveloped.

Tapo Alto Shell Lime and Fertilizer Company has leased the deposit formerly known as the *Gillibrand Limestone Deposit.* J. E. Franklin, 4336 Victoria Park Drive, Los Angeles, is president of the company. Owner, Mrs. E. C. Gillibrand, Santa Susana, California.

The deposit which is 5 miles north of Santa Susana, a station on the Southern Pacific Railroad, is in Sec. 17, T. 3 N., R. 17 W., S. B. B. and M.

This deposit occurs on the west slope of the Santa Susana Hills. The axis of these hills has a NW.-SE. trend and here they appear to be largely composed of limestone, while farther to the southeast, sandstone seems to predominate. The shell lime deposit is on the very top of the Tapo Alto Mountain. Locally the strike is southeast with a dip of about 25° to the southwest. It is reported that it is traceable for a distance of about $3\frac{1}{2}$ miles to the southeast.

Present quarry is 200 feet long by 70 feet wide, with a 40-foot face. Material is handled by gasoline shovel, having a $\frac{1}{4}$-yard dipper, into a $1\frac{1}{2}$-ton truck which hauls it about 200 feet to the brow of the hill where it is dumped into a chute 300 feet long. This chute empties into a hopper which discharges into the boot of an elevator; to trommel screen, 4-mesh, screenings to bin, thence to elevator and Cottrell vibrating screens; products to two-compartment bin; oversize from trommel to rolls and bin. The plant is so arranged that either product can be put on dump by means of a conveyor. Plant is operated by 25-h.p. Fairbanks Morse gas engine. Plant has a daily capacity of about 15 tons. Products are $-8+10$-mesh for chickens and -10-mesh for little chicks.

Analysis by Smith Emery Company

CaO	54.64%
CO_2	42.86%
P_2O_5	0.07 to 0.33%
Insoluble Equivalent	2.07%
$CaCO_3$	97.50%

This material is also suitable for fertilizer and shipments for this purpose are being made from the reject dump by Fred R. Belton, 331 H. W. Hellman Building, Los Angeles.

Material from this dump is elevated to 14-mesh screen, screenings from which are sacked and shipped. Oversize goes to waste in the canyon.

Normally ten to twelve men are employed in the two operations.

Ventura Cement Company's deposit is in Matilija Canyon, 10 miles slightly north of west from Matilija Junction, a station on the Ojai Branch of the Southern Pacific Railroad. It comprises 400 acres of patented land. It is in Secs. 22, 23, 26 and 27, T. 5 N., R. 25 W., S. B. B. and M. Owner, Ventura Cement Company, Fred Hartman, president and secretary, 95 Jordan Avenue, Ventura, California.

The deposit occurs in a canyon which comes into the Matilija from the southwest and the outcrop crosses this canyon about one-half mile from the main canyon, at an elevation of approximately 1500 feet. As

exposed on the northwest side, in the bottom and head of the canyon the limestone is unaltered from its original state and is in at least two strata, separated by about three hundred feet of shale. These two strata are approximately 75′ and 175′ thick, respectively. The greater width here given may vary widely from the actual thickness, due to poor exposures. The sides of the canyon are thickly covered with brush which makes it very difficult to get over the ground. The deposit is traceable to the west into the next canyon, a distance of about one-half mile. Strike is east-west and it dips steeply to the south. The limestone is gray in color, fine-grained and compact.

FIG. 3. Ventura Cement Company's deposit is in this canyon.

Analyses

Volatile (CO_2)	34.54%	30.99	44.26	36.78	28.78
SiO_2	15.06	22.64	2.95	12.22	28.54
Al_2O_3 & Fe_3O_4	5.20	7.86	1.94	4.76	6.34
CaO	42.76	37.76	35.33	43.60	36.06
$CaCO_3$ (equiv.)	76.11	69.97	63.59	78.48	64.91

Other samples taken gave—$CaCO_3$ 93.93%, 97.86% and 93.50%.

Development work consists of opencuts on the side hill. Remains of an old kiln may be seen in the bottom of the canyon.

Idle.

MICA

A deposit of muscovite occurs on the northeastern slope of Alamo Mountain, in Secs. 12, 13, and 24, T. 7 N., R. 20 W., S. B. B. and M. The country rock is granite, gneiss, and mica schist. The mica occurs in a feldspar gangue, between a granite hanging and a mica-schist footwall. It is said that some sheets of mica 3 x 4 inches were mined, but that the product was mostly scrap mica. The deposit was developed by the Mount Alamo Mica Company of San Francisco in 1907. Workings caved. Abandoned.

MINERAL PAINT

South Mountain Deposit. Beds of soft red shales are exposed on the north slope of South Mountain. The thickness of the beds is about 60 feet, and they extend for several hundred feet. The material is of uniform brick red color, and pulverizes readily upon crushing, leaving little or no grit.

There was a small production from the deposit in 1923. The property has been in litigation.

MOLDING SAND

Deposits of molding sand occur on a ridge north of Ventura. The sand is exposed in Buena Vista Canyon, and also in another canyon to the east on the McElrea Ranch. The sand is very fine-grained, has a good bond, and has been used in local foundries. A considerable tonnage has been shipped to Los Angeles.

Ventura Velvet Molding Sand Deposit is located within the city limits of Ventura, on a ridge south of Buena Vista Canyon, a mile north of the Southern Pacific Railroad Station, at Ventura. Owner, Charles A. Cole, Ventura, California. Holdings consist of 28 acres.

A bed of unconsolidated sandy loam and fine-grained sand, said to be 100 feet thick, is exposed in the canyon. The quarry is 200 feet in length and 75 to 100 feet in height. The material is handled with scrapers to the bins, then screened through No. 4 mesh, revolving screen, oversize going to a set of rolls.

Quality: The sand is very fine-grained. About 96 per cent of the sand will pass through 100 mesh, and 48 per cent through 200 mesh. The sand has a good bond.

Analysis

Silica	66.25%
Iron oxide	8.75%
Aluminum oxide	12.75%
Calcium oxide	3.07%
Magnesium oxide	2.70%
Alkalies	2.40%
Loss in ignition and undetermined	4.33%
Total	100.25%

PETROLEUM AND NATURAL GAS

Ventura County production of petroleum for the year 1930 amounted to 19,983,341 barrels valued at $27,896,744. In addition to this, natural gas was reported as valued at $3,749,829.

The producing oil fields occur in the south central portion of the county. The principal productive fields of the county are Barsdale, Ojai, Piru, Santa Paula, Sespe, Simi, South Mountain, and Ventura. For detailed description of the different oil fields of the county, see Bulletin No. 69, 'Petroleum Industry of California'; also State Oil and Gas Supervisor's Annual Reports.

Bibliography: State Mineralogist's Reports VII, p. 101; VIII, p. 684; XII, p. 357; XIII, p. 585; Bulletins 11, 19, 32, 63, 69, and 89. U. S. Geol. Surv. Bulletin 309, 691m, 753. Summary of Operations, California Oil Fields, Vol. 5, No. 8; Vol. 10, No. 5.

PHOSPHATES

Small deposits of white phosphates occur along the top of South Mountain, four miles south of Santa Paula, on the homestead of Joshua

FIG. 4. Block of brown sandstone. Sespe Canyon, Ventura County.

Stockton. These phosphates are in a thin stratum scattered through the soft sandstone which crumbles readily in the hand. The owner reports that samples of the material sent to Los Angeles for analysis contained 5 per cent calcium phosphate. Undeveloped.

SANDSTONE

The sandstone industry of the county has greatly decreased in the past few years, and only one quarry remains at which any stone has recently been quarried. For many years building stone was quarried from the large boulders and broken slabs of the Sespe brownstone in Sespe Canyon. This is a hard brown sandstone, uniform in texture and color and very resistant to weathering as shown by the bold outcropping ledges and the fresh surfaces of the broken slabs. Massive

beds of buff-colored sandstone outcrop two miles east of Santa Susana. Beds of white siliceous sandstone outcrop in Matilija Canyon. Some building stone was cut from the boulders of this tough sandstone at Wheelers Hot Springs for local use.

Santa Susana Quarry is located in Sec. 16, T. 2 N., R. 17 W., S. B. B. and M., two miles east of Santa Susana. Massive beds of buff-colored sandstone were quarried by the Southern Pacific Railroad Company, and the stone used for rip-rap work along the road bed. The sandstone proved to be too soft for this purpose. Idle.

Bibliography: Bulletin 38, p. 327.

Sespe Canyon Brownstone Quarry is in Sec. 35, T. 5 N., R. 20 W., and Sec. 2, T. 4 N., R. 20 W., S. B. B. and M. George J. Henley, Sespe, owner.

The quarry is five miles north of Brownstone, a station on the Southern Pacific Railroad. The brown sandstone is exposed on both sides of the Sespe River. It is also exposed in the the small tributary canyons such as Coldwater Canyon, east of the river. On the north side of the river the brown sandstone occurs in heavy, massive beds, with two sets of nearly rectangular joint planes, so that it lies in huge cubical blocks which have a gentle dip to the north and east. The brownstone series consist of sandstones, shales, and conglomerates, with a total thickness of 800 feet or more. On the hill west of the river about 800 feet above it, the shales have been eroded, exposing the top of the sandstones over a large area. A number of water-courses have cut deep tributary canyons into this hill, exposing the edges of sandstone layers, from 15 to 20 feet thick, and in places forming perpendicular cliffs from 30 to 50 feet in height.

Good quarries of excellent brownstone could be opened at many places in this hill. The stone is a typical brownstone; the coarser-grained varieties have a rich purplish-brown color, and the finer-grained stone is a light reddish brown. Very little stone has been cut from the sandstone layers, and most of the material shipped has been quarried from boulders in Sespe Canyon. This material has been used in a great many buildings in different cities in California. Six thousand cubic feet of the stone were used in the Methodist Episcopal Church at Pasadena during 1924.

Massive beds of hard white siliceous sandstone are exposed on the north side of Coldwater Canyon. Only a small amount of stone has been quarried from this deposit. This white sandstone rests conformably on the brownstone. Only assessment work has been done.

Bibliography: Bull. No. 11, p. 26; No. 19, p. 94; No. 38, pp. 142–145.

STONE INDUSTRY

The rapid growth of the cities and towns of Ventura County has caused an increased demand for building materials, especially crushed rock, sand, and gravel. These materials are also used for construction of buildings, concrete and road work. A number of gravel and sand plants are under operation on the Santa Clara and Ventura Rivers.

CRUSHED ROCK, SAND, AND GRAVEL PLANTS

El Rio Sand and Gravel Company, Box 381, Ventura, California, has a plant in the bed of the Santa Clara River, five miles east of Oxnard and three-quarters of a mile north of the Santa Paula-Oxnard highway.

The present pit is about 250 feet long, 150 feet wide by 50 feet deep. Material is excavated by dragline, over 10-inch grizzly to hopper, thence by 20-inch belt to Wheeling jaw crusher, which discharges into the boot of an elevator; elevated to 3-foot by 18-foot revolving screen; screen openings are 1½-inch square, ¾-inch round, ⅜-inch round; ¼-inch round, 8-mesh and 12-mesh. Screenings from 8- and 12-mesh go to two dewatering drags; overflow back to pit. Bin has eight compartments with a total capacity of 350 yards.

Two men are employed at the plant.

Fillmore Rock Company's plant is one mile southwest of Fillmore in the bed of the Santa Clara River. Owners, Dewey I. Jordan and Pearl B. Jordan, both of Fillmore, California.

Sand and gravel are handled by steam shovel and crane. The washing and screening plant has a capacity of about 100 cubic yards. Bin capacity 60 yards. Products are used for general building and road work.

Four men are employed.

Piru Rock Company, Ltd., has a plant in the Santa Clara River valley one-quarter mile east of the town of Piru. The property, consisting of two thousand acres is leased from the Canulos Ranch Corporation. Officers of the Piru Rock Company are H. W. Jones president, and George H. Grabe, secretary, Piru, California.

The type of the material in the deposit varies considerably but where opened by the present pit, it runs about 60% over ¼ inch in size with some boulders up to 24 inches. Present pit is circular about 60 feet in diameter by 45 feet deep. It is planned to work to a depth of 100 feet.

Material is loaded into hopper by a Koehring, 1-cubic yard gasoline shovel; thence by 30-inch Bodinson feeder to 30-inch belt conveyor, 300 feet center to center, which carries material up and out of the pit to a hopper; thence to 30-inch conveyer, 120-foot centers, to the top of the scalping and crushing buildings. Here the conveyor discharges to a 48-inch by 10-foot revolving scalping screen, with 2½-inch perforations on inner jacket and ⅜-inch wire mesh cloth on the outer jacket. The screenings to an 18-inch conveyor, 120-foot centers to stock pile or discharges onto another conveyor, to give additional stock pile capacity. About 50% of the sand in the material is stored unwashed, the other half going with the gravel to the screening plant.

The 'middlings' from the double jacketed trommel (through 2½-inch and on ⅜-inch) go directly to 24-inch inclined conveyer, 220 foot centers (No. 3), which goes to the top of the screening plant. Material over 2½-inch is fed to Traylor No. 12 gyratory crusher which discharges onto 24-inch inclined conveyor, 198 foot centers (No. 5).

The screening plant consists of two 48-inch by 22-foot Austin revolving screens, one of which is used for sizing gravel and the other

for crushed rock. Conveyor No. 3 feeds the gravel screen and conveyor No. 5 the stone screen. The screens are supported on a timber bin structure composed of two separate bin structures of five compartments each with a total combined capacity of 750 tons. One is used for gravel and sand and the other for crushed gravel.

The gravel screen has 10 feet of ½-inch, 7 feet of 1-inch and 5 feet of 1½-inch wire cloth on the main barrel and 9 feet of $\frac{3}{16}$-inch cloth on the outer jacket. This arrangement produces pea gravel and ¾-, 1½- and 2½-inch gravels and sand. The four sizes of gravel are discharged directly through chutes to the bins. The sand passing through the sand jacket goes to a sand washer of the company's design and construction; this removes the fine sand and silt and produces a clean concrete sand.

The stone screen has 7 feet of ½-inch, 7 feet of 1-inch and 5 feet of 1½-inch cloth on the main barrel and a 6-foot outer jacket with $\frac{3}{16}$-inch cloth. The main barrel also has a 3-foot section of 2½-inch perforated plate. This screen produces five sizes of commercial rock: 2½-, 1½-, ¾-, ½- and ¼-inch sizes, numbered 1 to 5 respectively under the present California state specifications. The 'oversize,' over 2½-inch, is chuted to a 24-inch horizontal conveyor (No. 4), 80 feet long between centers, running between the two bin sections. This discharges to a separate 50-ton timber bin, which can discharge from one side into cars for +-2½-inch macadam rock base. This bin can also feed from below to a 24-inch inclined conveyor (No. 9), 80 feet long between centers, which feeds a Traylor 6-inch reduction crusher under the scalping building and alongside the secondary crusher. This crusher is of the latest type with a curved concave and mantle. It discharges to conveyor No. 5 leading back to the stone screen.

Trucks are loaded from any of the 10-bin compartments through side gates. When cars are being loaded the aggregate is fed through side gates near the bottom of the bins to a 24-inch horizontal belt conveyor (No. 6), 50 feet long between centers, which runs between the two bin sections at ground level. By means of this conveyor separate sizes or any mixture of sizes can be loaded. This belt feeds at right angles to an inclined loading belt (No. 10), which is 24 inches wide and 90 feet long between centers. A series of sprays over a perforated plate give a final rinse to the aggregate. A flop gate under this plate allows loading to trucks on one side and to cars on the other. Trucks are generally loaded here only when a mixed gravel is desired. When sand is being loaded the perforated plate is covered.

A storage track with a capacity of 30 cars is now being built and materials will later be stock-piled on both sides of this track. A gasoline locomotive-crane will be purchased for rehandling this material.

A Plymouth 12-ton locomotive with a Climax gasoline engine is being used for switching cars and 'spotting' them for loading. A P & H gasoline crawler crane with a 1¼-cubic yard Owen clamshell bucket is used for rehandling the stock-piled sand.

Individual motors drive the various machines. Power is supplied by the Southern California Edison Company. Plant has a capacity of 200 tons per hour. Materials for Sixth Street viaduct in Los Angeles were supplied by this company.

Ten men are employed.

Bibliography: Pit and Quarry, Oct. 21, 1931, pp. 20–23.

Santa Paula Rock Company's plant is in the bed of the Santa Clara River, just south of the town of Santa Paula. Owners, A. N. Vela and Ramon Prieto, Santa Paula, California.

The former plant was carried away by the rush of water from the St. Francis dam failure. The new plant has only recently been completed. It is very well constructed, all substructures being of massive concrete.

Material from the river bed is loaded into 5-yard cars by gasoline crane with a one-yard bucket. Cars are hauled approximately one thousand feet to plant by 8-ton Plymouth gasoline locomotive. Cars dump into field bin over a 10″ grizzly; oversize is stored in the yard. From bin a 24″ conveyor carries material to a double deck conical screen, $1\frac{3}{4}''$ and $1\frac{1}{4}''$, oversize to bins; screenings to 2 conical screens $\frac{1}{2}''$ and $\frac{1}{4}''$, oversize to bins; screenings to sand dewatering tank. Bins have seven compartments for 2 sand and 5 rock products. Bin capacity is 320 yards.

Seven men are employed.

S. C. Sand and Gravel Company, Box 1002, Ventura, California; J. T. Raleigh, president; L. R. Howards, secretary.

FIG. 5. Santa Paula Rock Company's plant.

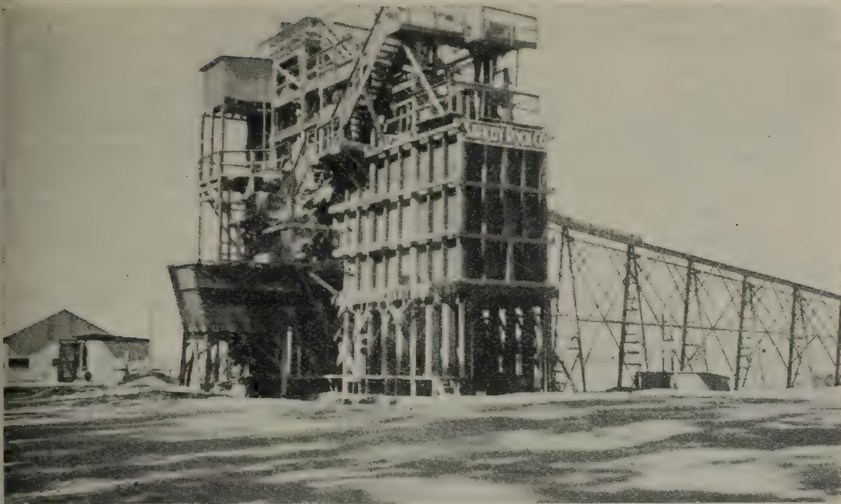


FIG. 6. Saticoy Rock Company gravel plant. Saticoy, Ventura County.

This plant is in the bed of the Santa Clara River about 6 miles southeast of Ventura and one-quarter of a mile west of Ventura Boulevard. It was built in 1928.

The material is excavated by Northwestern crane dragline with one-yard bucket and dumped into 5-yard cars. A 7-ton Plymouth gasoline motor hauls 3-car trains over 1200′ of track, where it is dumped over an 8″ grizzly into a hopper; oversize is broken so that everything goes through. From the hopper a reciprocating feeder discharges onto a 20″ conveyor to conical revolving screen, 2″ round holes; oversize to No. $3\frac{1}{2}$ Wheeling crusher, discharge and screenings elevated to $1\frac{3}{8}''$ revolving screen; oversize to No. $2\frac{1}{2}$ Wheeling crusher, back to same elevator. Screenings from $1\frac{3}{8}''$ to $\frac{7}{8}''$ revolving screen, thence to $\frac{1}{4}''$ or $\frac{1}{8}''$ revolving screen. Five products are made, 3 sizes of gravel, concrete and plaster sand. Bins have a capacity of 4000 yards. Plant capacity is 300 yards a day.

Ten men are employed.

Saticoy Rock Company, Fred Smith, president; Robert Mitchell, secretary; A. H. Stovall, manager, Saticoy. The crushing plant is located on the Santa Clara River, one mile southeast of Saticoy. The company controls 1000 acres along the river. The capacity of the plant is 550 yards per nine-hour day.

The gravel from the pits is loaded into a train of three side-dump cars, having a capacity of four yards each, by a Byers Model No. 10 bucket hoist. The cars are hauled by a Plymouth 7-ton gasoline motor to storage bins, where they are dumped over a grizzly, the bars being spaced ten inches apart.

All boulders that will not pass the grizzly are stored in the yard. From the receiving bins the 10-inch and finer gravel is transported by 30-inch belt conveyor to a No. 4 Universal crusher, where it is crushed to pass a 3-inch ring. The product from the crusher is elevated

by bucket elevator to a Gilbert system of screens. The oversize material from the screening plant goes to an 8-inch by 36-inch jaw crusher, and is re-elevated to the screening plant. The material passes through Gilbert revolving screens, making the following products: $2\frac{1}{2}''$, $1\frac{3}{4}''$, $1\frac{1}{4}''$, $\frac{1}{2}''$ to $\frac{1}{4}''$, and sand. The sand goes to two 12-inch log washers.

The capacity of the storage bunkers for the product is 480 yards. Trucks are loaded by means of gates from each bin. Electric power is used to operate the plant, the total power being 137 horsepower. The cost of operation varies from 50 to 60 cents per yard. Eight men are employed.

Ventura Rock and Sand Company, W. T. Rodman, Ralph T. Ogilvie, and John Ward of Ventura, owners. The company operates two plants; one is located on the Santa Clara River, one-half mile south of Montalvo; the other on the Ventura River within the city limits of Ventura. No. 2 Plant. At the Montalvo plant the material is taken from the river and is hauled by scrapers to the hopper. It then passes through a No. 2 Universal crusher; the crushed material is elevated to a revolving screen, where it is screened dry. Products produced are $2''$, $1\frac{1}{2}''$, $\frac{1}{2}''$–$\frac{1}{4}''$, and sand. Capacity of the plant is 150 yards per nine-hour day. Six men are employed.

No. 1 Plant. This plant is located $1\frac{1}{2}$ miles east of the bridge on the Ventura-Santa Barbara Highway, on the Ventura River. Boulders and rock are hauled from the river bed by wagons to the hopper, where it passes to a No. 3 Austin crusher and is crushed to pass a 2-inch ring. The crushed product is elevated to revolving screens. The products made are $1\frac{1}{2}''$, $1\frac{1}{4}''$, $1''$, and $\frac{1}{2}''$–$\frac{1}{4}''$. The capacity of the plant is 50 yards per nine-hour day. A 20-h.p. motor drives the plant. Six men are employed.

MINERAL SPRINGS

In Matilija Canyon, in Ventura County, thermal springs issue at several points from the shales and sandstones of Tertiary age.

Of these the Matilija Hot Springs and the Ojai or Vickers Hot Springs have had the most intensive development and are still maintained as resorts.

Matilija Hot Springs are 18 miles north of Ventura and approximately seven miles northwest of Ojai. Joe S. Linnell, proprietor, Ojai, California.

This has been a resort since about 1890. Development consists of a hotel and cottages, with accommodations for about two hundred people, also an outdoor plunge.

Here three warm springs issue from the banks of Matilija Creek. Maximum temperature is reported as being 116°.

Analysis of Water, Grains per U. S. Gallon, by Wade & Wade, Los Angeles

Fountains	$CaCO_3$	$MgCO_3$	Na_2CO_3	$NaCl$	SiO_2	$CaSO_4$	Na_2SO_4	*Total Solid Matter*	*Sulphur gas*
Fountain of Life	1.30	0.11	5.20	15.00	1.10	---	---	22.71	1.30
Mother Eve	5.66	3.36	---	3.52	1.00	3.63	2.90	10.07	0.90
Hot Sulphur Water	15.00	1.18	6.56	1.60	1.60	---	1.00	12.09	0.33

Ojai or Vickers Hot Springs are about 2½ miles northwest of the Matilija Springs. Owner, G. Anloff, 1031 South Broadway, Los Angeles.

These springs mark the westernmost point in the canyon where thermal waters are found. Here some thirteen springs issue from a bank of gravel and shale. Maximum temperature is reported as 131°. Development consists of a plunge and hotel which has recently been reopened as a resort.

Analysis of water from main spring, Vickers Hot Springs

(Analyst R. B. Riggs (1888). Authority, U. S. Geol. Surv. Bull. 60. Constituents are in parts per million)

Properties of reaction:

Primary salinity	87
Secondary salinity	2
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	11
Tertiary alkalinity	1

CONSTITUENTS

	By weight	*Reacting values*
Sodium (Na.)	546	23.72
Potassium (K)	32	.83
Calcium (Ca)	65	3.24
Magnesium (Mg)	3.4	.28
Sulphate (So$_4$)	17	.35
Chloride (Cl)	877	24.73
Carbonate (CO$_3$3	58	1.93
Silica (SiO$_2$)	41	1.37
	1,639.4	

GEOLOGIC BRANCH

CURRENT NOTES

By OLAF P. JENKINS, Chief Geologist

The recent revival of interest in gold mining has centered much attention on the northern Sierra Nevada, and has caused a demand for reliable information on the geologic history of this famous gold-bearing region. Since the classic works of earlier geologists, Lindgren and others, are now difficult to obtain, having long been out of print, the Geologic Branch has prepared a general geologic map and report of the area. The principal rock formations are shown and described, the compilation of which has been made possible through use of material assembled during the preparation of the new State geologic map, a project now under way in cooperation with the United States Geological Survey. The colored overprint of the map has been largely compiled by Miss Mary Balch, Geological Clerk of the Geologic Branch, and shows the Tertiary gravel deposits, the former positions of the main Tertiary streams, and the area covered by the Mother Lode system of veins. Besides these features, a number of important gold mines are indicated.

Following this more general report on the Sierra Nevada, is a pertinent contribution by Dr. Ralph Chaney, entitled ''Notes on occurrence and age of fossil plants found in the Auriferous Gravels of Sierra Nevada.'' The location of the collections discussed by him are shown on the geologic map, and therefore coordinated with the more general study. Determination of the geologic age of the fossils found in the interbedded shales of the auriferous gravels should throw considerable light on the correlation of the various ancient river channels. We wish to thank Dr. Chaney for permitting us to publish the results of progress made by him in this study.

Another study of special interest in the geology of the Sierra Nevada is that of glaciation. We highly appreciate, therefore, the contribution made by Dr. Eliot Blackwelder, who presents an instructive article on ''Glacial and associated stream deposits of the Sierra Nevada.'' Although it is well known that the last great event in geologic history was that of glaciation, this is the first time that a map showing the distribution of the ancient glaciers throughout the Sierra Nevada has appeared.

The fourth geological paper appearing in this issue has been contributed by Dr. Frank M. Anderson, on the revision in interpretation of the ''Jurassic and Cretaceous divisions in the Knoxville-Shasta succession of California.'' We are pleased to be able to publish this notable contribution to the sedimentary geology of the State, especially as it concerns a great thickness of strata exposed in northern California, where there has been much exploration made recently by oil geologists.

The fifth contribution, ''Geology of a part of the Panamint Range, California,'' is by F. M. Murphy and represents the results of a very careful geologic investigation of an interesting region lying west of Death Valley in which considerable mining activity has lately been shown.

REPORT ACCOMPANYING GEOLOGIC MAP OF NORTHERN SIERRA NEVADA

By Olaf P. Jenkins, Chief Geologist, Geologic Branch

PURPOSE OF THE REPORT AND ACCOMPANYING MAP

The accompanying geologic map of northern Sierra Nevada has been prepared to meet the present demand for geological information of this important gold-producing region. The map (in pocket) shows four principal features:

(1) The surface areas covered by each of the principal groups of geologic formations.

(2) The principal exposed gravel deposits of the ancient gold-laden Tertiary streams and the general direction of their major channels. In addition, localities are indicated where fossils have been found associated with the auriferous gravels.

(3) The area covered by the Mother Lode system of veins.

(4) The location of some of the principal gold mines of the region.

A summary of the principal events in the geologic history of the region is presented in this brief report in order that the map may be more easily understood and the geologic features more readily interpreted.

PROJECT OF THE NEW STATE GEOLOGIC MAP

The geologic map of the northern Sierra Nevada, which this report accompanies, represents an advance sheet, subject to revision. It has been prepared in somewhat generalized form, traced from a part of the unpublished new State Geologic Map, which is one of the main projects of cooperative work between the U. S. Geological Survey and the Geologic Branch of the California State Division of Mines. When completed and published the State map will measure seven feet high, drawn on the scale of 1 : 500,000, or approximately eight miles to the inch. It will show, in various colors, patterns, and symbols, about 60 different geologic units or formations.

The first preliminary copy of the State map has been actually drawn in Washington, D. C., under the direction of G. W. Stose, map editor of the Federal Survey. Completion of the map as well as revision of various parts of it, however, will take several years of continued study, including much actual field work, and this part of the undertaking is being done by the State Geologic Branch.

The whole undertaking represents well-organized and carefully coordinated research. In its construction, care has been taken to make the map as easily understood as possible, and emphasis is laid on features which have a particular bearing on things of economic concern.

GENERAL FEATURES AND LOCATION OF THE AREA

The area covered by the geologic map which this report accompanies is located between meridians 37° 20′ and 40° 30′ and parallels 120° and 122°, and represents the northern part of the Sierra Nevada,

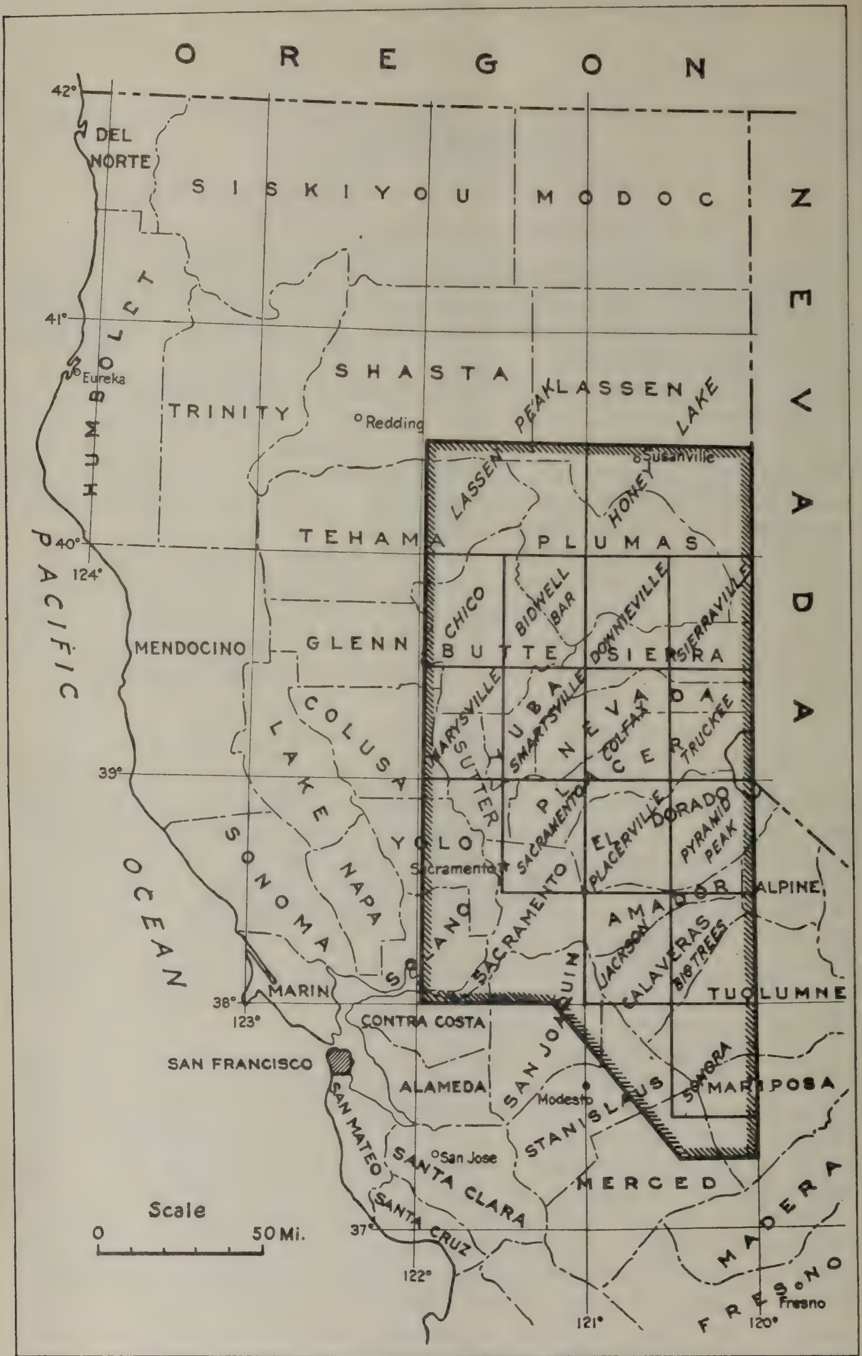


FIG. 1. Index map of northern California showing area covered by Geologic Map of Northern Sierra Nevada. The principal topographic quadrangles of the U. S. Geological Survey are also outlined and named. All of these, excepting the Chico, Sierraville, and Honey Lake, are covered by the geologic folios of the Federal Survey.

a major physiographic province of California. The rectangle under discussion is 200 miles long by 100 miles wide. Bordering this mountainous province on the north, is an extensive lava-covered region. To the east of the Sierra Nevada is the Great Basin province. On the west, lies the Great Valley of California, a plain through which the Sacramento River, flowing south, meets the San Joaquin River, flowing north; united they enter the waters of San Francisco Bay.

The northern Sierra Nevada differs materially from the southern part of the range. The former is comprised of a large number of different sedimentary and metamorphic rocks, intruded by granites, veined with quartz, traversed by a system of ancient river channels, and capped by lava; while the more southern part of this stately mountain range with snow-capped peaks is composed almost exclusively of massive granite of scenic grandeur. Geologically the northern part is more complex; economically it has produced the most mineral wealth, particularly gold; and historically it is known throughout the world, especially by the writings of Bret Harte and Mark Twain.

The range as a whole is a west-tilted, up-raised block of the earth's crust. Its crestline follows in close proximity to its eastern front, scarped by prominent faults of recent geologic date.

SOURCE OF DATA

The following selected references give the most important sources of published information which have been used in writing this report and in the preparation of the accompanying geologic map of northern Sierra Nevada:

Allen, Victor T., The Ione formation of California: California Univ. Dept. Geology Bull., vol. 18, pp. 347–448, 1929.

Blackwelder, Eliot, Pleistocene glaciation in the Sierra Nevada and the Basin Ranges: Geol. Soc. America Bull., vol. 42, pp. 865–922, 1931.

Browne, Ross E., The ancient river beds of the Forest Hill divide: California State Min. Bur. Tenth Ann. Rept., pp. 435–465, 1890.

Browne, Ross E., The channel system of the Harmony Ridge, Nevada County: California State Min. Bur. Twelfth Ann. Rept., pp. 202–203, 1894.

Bryan, Kirk. Geology and ground-water resources of Sacramento Valley, California: U. S. Geol. Survey Water-Supply Paper 495, 285 pp., 1923.

Cloos, Ernst, Structural survey of the granodiorite south of Mariposa, California: Am. Jour. Sci., 5th ser., vol. 23, pp. 289–304, 1932.

Diller, J. S., Tertiary revolution in the topography of the Pacific coast: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 32–52, 1894.

Diller, J. S., U. S. Geol. Survey Geol. Atlas, Lassen Peak folio (No. 15), 1895.

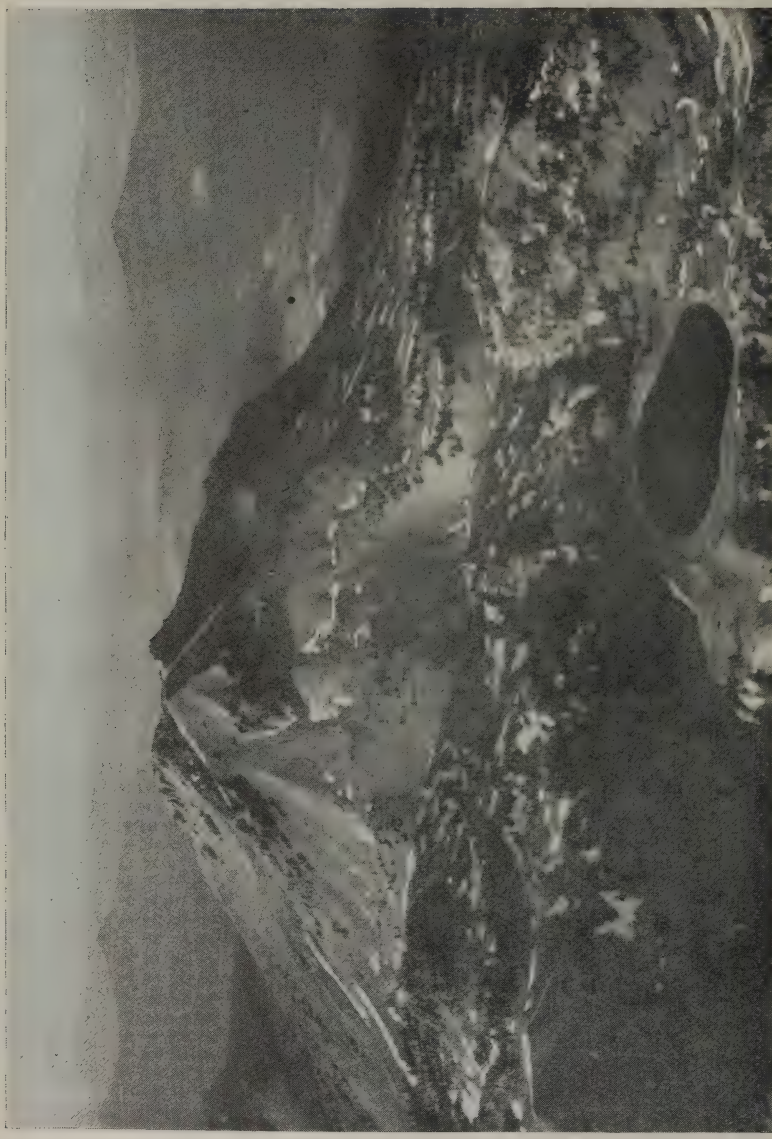
Diller, J. S., Geology of the Taylorsville region, California: U. S. Geol. Survey Bull. 353, 128 pp., 1908. Includes geologic map of Indian Valley and south half of Honey Lake Quadrangle by J. S. Diller and J. Storrs.

Ferguson, H. G., and Gannett, R. W., Gold quartz veins of the Alleghany district, California: U. S. Geol. Survey Prof. Paper 172, 139 pp., 1932.

Haley, C. S., Gold placers of California: California State Min. Bur. Bull. 92, 167 pp., 1923.

Knopf, Adolph, The Mother Lode system of California: U. S. Geol. Survey Prof. Paper 157, 88 pp., 1929.

Lindgren, Waldemar, Two Neocene rivers of California: Geol. Soc. America Bull., vol. 4, pp. 257–298, 1893.



Photograph by courtesy of G. E. Russell.

FIG. 2. Airplane view of Lassen Peak, looking NW. Helen Lake in foreground. Volcanic country in the distance. This region belongs properly to the Cascade Mountains province and not to that of the Sierra Nevada, which adjoins it on the south. The extruded volcanic rocks overlie the older granites and metamorphic formations of the Sierra Nevada.

Lindgren, Waldemar, and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Placerville folio (No. 3), 1894.

Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Sacramento folio (No. 5), 1894.

Lindgren, Waldemar, and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Marysville folio (No. 17), 1895.

Lindgren, Waldemar, and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Smartsville folio (No. 18), 1895.

Lindgren, Waldemar, The gold-quartz veins of Nevada City and Grass Valley districts, California: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 2, pp. 13–262, 1896.

Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Nevada City special folio (No. 29), 1896.

Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Pyramid Peak folio (No. 31), 1896.

Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Truckee folio (No. 39), 1897.

Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.

Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, 226 pp., 1911.

Matthes, F. E., Geologic history of the Yosemite Valley: U. S. Geol. Survey Prof. Paper 160, 137 pp., 1930.

Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Mother Lode district folio (No. 63), 1900.

Smith, J. P., The geologic formations of California, with reconnaissance geologic map: California State Min. Bur. Bull. 72, 47 pp., with map, 1916.

Stearns, H. T., Robinson, T. W., Taylor, G. H., Geology and water resources of the Mokelumne area, California: U. S. Geol. Survey Water-Supply Paper 619, 402 pp., 1930.

Storms, W. H., Ancient channel system of Calaveras County: California State Min. Bur. Twelfth Ann. Rept., pp. 482–492, 1894.

Turner, H. W., The rocks of the Sierra Nevada: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 441–495, 1894.

Turner, H. W., U. S. Geol. Survey Geol. Atlas, Jackson folio (No. 11), 1894.

Turner, H. W., Further contributions to the geology of the Sierra Nevada. U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, pp. 521–762, 1896.

Turner, H. W., U. S. Geol. Survey Geol. Atlas, Downieville folio (No. 37), 1897.

Turner, H. W., U. S. Geol. Survey Geol. Atlas, Bidwell Bar folio (No. 43), 1898.

Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (No. 41), 1897.

Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Big Trees folio (No. 51), 1898.

Whitney, J. D., The auriferous gravels of the Sierra Nevada: Mem. Mus. Comp. Zool. Harvard Coll., vol. 6, 569 pp., 1879. Includes chapters by W. A. Goodyear and W. H. Pettee.

Williams, Howel, Geology of the Marysville Buttes, California: California Univ. Dept. Geology Bull., vol. 18, pp. 103–220, 1929.

In addition to these sources, unpublished data have also been used in the preparation of the map. One item in particular is a "Recon-

naissance geologic map of a portion of northern California compiled from various sources with additional field data" by R. Dana Russell.

GEOLOGIC UNITS SHOWN ON THE MAP

A legend is shown on the Geologic Map of Northern Sierra Nevada which indicates the meaning of the various symbols used on the map. Each symbol represents a distinct geological formation or group of formations and the whole series is arranged chronologically. That is, the youngest appears at the head of the list, while the group names of the older rocks are indicated below it in descending order. The rocks of each group have been described in published literature elsewhere. In most cases they have been indicated on maps of larger scale in a more detailed manner than shown here.

The name 'Bedrock series' has often been employed to include all the older rocks, comprising both the metamorphic series and the igneous rocks which intrude it, while the name 'Superjacent series' has been applied to the gravel deposits together with the Tertiary volcanic materials. The quartz veins were formed prior to the 'Superjacent series,' while the placer gold belongs to this later series.

EXPLANATION OF GEOLOGIC LEGEND

QUATERNARY

Qal *Alluvium*

Deposits by recent streams, consisting principally of gravel and sand covering areas of considerable extent.

Ql *Lacustrine and playa deposits*

Deposits in recent lakes, generally of fine-grained silt.

Qt *Terrace alluvial deposits*

Stream gravel and sand found in the older benches and terraces.

Qg *Glacial deposits*

Only the more extensive glacial deposits (moraines, etc.) are shown in this unit; unsorted boulders, gravel, sand, clay, etc.

Qv *Chiefly Pleistocene volcanics*

Lavas, chiefly basalt, extruded later than Tertiary but earlier than Recent flows.

QP *Quaternary and Pliocene sediments (chiefly nonmarine deposits)*

Clay, sand and gravel, in general of a red-brown color and in places more or less consolidated; for the most part, the material is of the old alluvial fans; in some places the gravels are auriferous.

TERTIARY

Pliocene

Tlb *Late Tertiary lake beds*

Areas covered by these local deposits are rather limited in size.

TPu *Upper Pliocene nonmarine deposits (Tuscan tuff, etc.)*

This formation consists of sandstone, conglomerate, volcanic tuff, breccia, and agglomerate.

TPv *Pliocene volcanics (chiefly basalt)*

Some of these rocks represented by this unit have been considered to be of Quaternary age.

Miocene

TMv *Miocene volcanics and continental deposits (lava flows and tuffs of rhyolite, basalt, latite, and andesite)*

These rocks constitute the main mass of Tertiary volcanic material. The intervolcanic Tertiary river channels, shown on the overprint, are interbedded and a part of this series of Tertiary volcanics.

Eocene

TEm *Eocene marine deposits (Ione formation)*

These sediments are for the most part marine. The older Tertiary river gravels. composed largely of white quartz pebbles and the gravel deposits mapped on the overprint as Tg, are probably of the same age as the Ione formation. The early Tertiary streams apparently emptied into bodies of water in which the Ione formation was deposited.

CRETACEOUS

K *Cretaceous marine deposits (chiefly upper Cretaceous or Chico formation)*

These beds consist of shales, sandstones, and conglomerates, containing characteristic Chico fossils. Exposures of lower Cretaceous (Knoxville and Horsetown) are entirely lacking in this area.

JURASSIC

Jai *Acidic intrusives (granite, granodiorite, gabbro, etc.)*

This massive series of rocks represents the main body of the great granite batholith of Sierra Nevada. The time of intrusion was probably late in the Jurassic.

Jbi *Basic intrusive (diabase, amphibolite, and hornblende schist)*

The age of the intrusion of these rocks is post-Calaveras. They may be in part of Mariposa age but largely pre-Mariposa. Their association with the Mother Lode belt give them an economic significance.

Late Jurassic

Jub *Ultra-basic intrusives (peridotite, pyroxene, serpentine, etc.)*

These rocks represent the oldest of the post-Mariposa intrusives. The serpentines are hydrothermally altered products of such rocks as peridotite. They are of economic interest because of their prevalence in the Mother Lode belt.

Upper Jurassic

Ju *Upper Jurassic marine deposits (chiefly Mariposa formation)*

A metamorphic sedimentary series, consisting largely of black slate and graywacke with greenstone, a prominent associated formation in the Mother Lode belt.

JURASSIC AND TRIASSIC

JTR *Jurassic and Triassic volcanic and sedimentary rocks (includes about 16 individual formations)*

In the northern end of Sierra Nevada this group is represented by various formations which have been differentiated elsewhere on geologic maps of larger scale accompanying the original reports of the U. S. Geological Survey.

CARBONIFEROUS

C *Pennsylvanian and Mississippian sedimentary and igneous rocks (includes the Robinson formation, Calaveras group and other rocks of the Carboniferous period)*

This series of metamorphic sediments includes rocks older than the Mariposa slate. Though usually considered to be of Carboniferous age, the Calaveras formation may include both older and younger rocks. In the Mother Lode

belt this formation consists chiefly of black phyllite with subordinate fine-grained quartzite, limestone and chert.

DEVONIAN AND SILURIAN

DS *Devonian and Silurian marine deposits* (*Taylorsville, Grizzly, and Montgomery formations*)

These sedimentary rocks exposed in the northern end of Sierra Nevada, are the oldest known of the Paleozoic section in this region. They consist of quartzite, slate, and some limestone.

AGE UNKNOWN

pK *Pre-Cretaceous metamorphic sedimentary complex.*

pS *Pre-Silurian meta-rhyolite*

These rocks are shown by the same map symbol, located in the northern end of Sierra Nevada; they represent undifferentiated metamorphic series the age of which has not been determined.

GEOLOGIC HISTORY OF THE REGION MAPPED

As seen by the chronologically arranged list of geologic units used on the map of the region under discussion, the record of past events in geologic history is nearly complete, being well represented by rocks of various ages, from a time before the Paleozoic to the present. The three main classes of rocks are found, i.e., sedimentary, igneous, and metamorphic.

A detailed account of the geologic history of the Sierra Nevada as it may be interpreted from known facts, would be a very long story. Briefly, the principal events may be summarized as follows:

The events of pre-Paleozoic time are very indefinite and the record is hardly recognizable. Some of the older schists and metamorphic igneous rocks may be of this very ancient period. It is possible that in Cambrian time, the beginning of the Paleozoic era, a mountain range stood where the Sierra Nevada now is located.

The Paleozoic (comprising the Cambrian, Ordovician, Silurian, Devonian, and Carboniferous) is represented for the most part by several geological formations considered to be of Carboniferous age. In the northern end of the Sierra Nevada, however, the presence of a number of marine sedimentary formations show that the sea covered part of this area during the Silurian and Devonian. Unconformities between formations show that there were elevations and submergences of the land which caused frequent fluctuations in the relative position of land and sea.

The beginning of the Carboniferous shows evidence of marine deposition, but this was followed by intrusive igneous activity. Though it subsided, and widespread marine limestones were again formed, another period of igneous activity was repeated and a general uplift of the Sierra Nevada was initiated. Later, metamorphic action became very intense, especially in the southern part of the region, where the individual formations of this series can not now be differentiated, and the name Calaveras formation is used, even though the unit may include formations of both older and younger periods. In the north, however, metamorphic action was not so great and a number of separate formations are recognized and shown on the larger-scale published maps.

Of the rocks representing the Mesozoic era (which includes Triassic, Jurassic, and Cretaceous) the Jurassic is the most complete. In the Triassic, marine deposition was prominent though some igneous activity occurred. In the Jurassic not only were sediments formed, but much igneous activity prevailed, especially during the latter part of that period, when an enormous series of intrusive magmas invaded the formations.

The earliest intrusions are represented by igneous rocks which are considerably metamorphosed. Basic magmas were followed by the more acidic. The greatest of intruders was the granite batholith, comprised of granite, diorite, granodiorite, gabbro, and other such holocrystalline deep-seated igneous rocks. The emplacement of this acidic magma which extended far beyond the bounds of the Sierra Nevada, the metamorphic action it had on the previously formed and deformed rocks which it intruded, and the release of accompanying mineralizing solutions which invaded crushed zones of the surrounding rocks to form ore deposits, were events of such importance that they have had an everlasting effect upon civilization.

On the map under discussion, a large number of formations, of both Triassic and Jurassic age are grouped together, though elsewhere on large-scale maps they are separated. One undifferentiated metamorphic series, of Upper Jurassic age, known as the Mariposa formation, is so intimately associated with the Mother Lode system that it has been shown as a single unit on the State map.

Since the granite invasion followed the deformation and uplifting that began in late Carboniferous time, it is thought that the two actions—uplift and intrusion—were in some way genetically related. After the intrusion had apparently ceased, a different kind of earth movement was initiated. Where folding and igneous invasion typified the orogenic actions preceding the Cretaceous period, faulting and extensive movements of solid blocks or segments of the earth's crust have marked the type of active mountain building that has since taken place. Block movements of this sort have continued down to the present time.

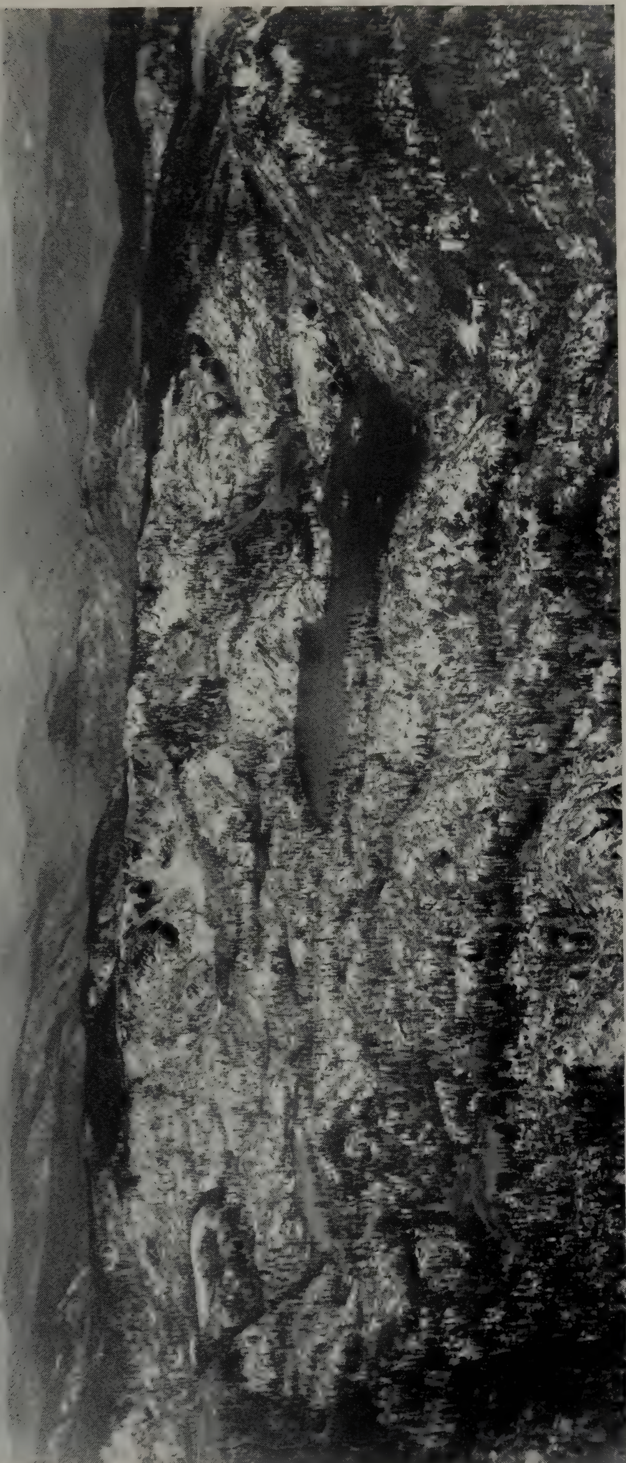
During early Cretaceous, the region was greatly eroded and reduced to a surface in places gently undulating, though on the whole still mountainous. The geologic structure, marked by long northwest-southeast folds and faults, controlled the topographic relief, so that the mountain range may have appeared somewhat similar to the Appalachians of today. Subsidence in parts farther to the northwest and west allowed deposition of sandstone and conglomerate in the west-bordering Chico sea (Upper Cretaceous). Beginning at this same time and continuing during the epochs that followed, the Sierra Nevada was uplifted, breaking away from the Great Basin region along huge faults that are still found active along the eastern front of the range. The total erosion that took place during the Cretaceous and Eocene removed a cover the thickness of which varied, but probably averaged about two miles, measured vertically.

There has not yet been completed sufficient stratigraphic work to differentiate in mapping the representatives of all of the various epochs of the Tertiary (Eocene, Oligocene, Miocene, and Pliocene). In general, however, the significant historical events of the Tertiary seem to

4—97834

Photograph by courtesy of G. E. Russell.

FIG. 3. Airplane view in northern Sierra Nevada north of Sierra City, looking SW. across the old evenly sloping surface (now dissected by stream-canyons) on which auriferous gravels were deposited by the ancient Tertiary streams, and later buried by volcanic materials. Upper Salmon Lake, to the right; Sierra Buttes, to the left beyond representing a vestige of Lindgren's pre-Tertiary divide, a fragmentary record suggesting the topography of greater antiquity.



Photograph by courtesy of G. E. Russell.

FIG. 4. Airplane view, forming with Figure 3, to the left, a panorama. Gold Lake, and the glaciated region about it, are in the foreground, while the canyon of North Fork of Yuba River may be seen in the distance, cutting through the sloping Tertiary 'peneplain.'

have been as follows: Before the eastern scarps were developed, the mountain range was nearly symmetrical in shape, but the western slope was somewhat steeper than the eastern. Evidence of a long northern-flowing stream shows that a slope extended in that direction also. The western Eocene streams, cutting the deeper channels, apparently diverted some of the drainage of the eastern-flowing streams, causing the older rugged Cretaceous crest line (shown by Lindgren to have passed through Sierra Buttes southeastward to Pyramid Peak) to be abandoned and a new Tertiary divide to hold a position farther to the east.

The Tertiary streams flowing down the western and northern flanks of the ever-moving mountain range, found it necessary to be continually adjusting their courses. Then came the Miocene outpourings of lava and volcanic breccia which covered much of the older river system, entombing their gravel deposits, filling in the valleys and producing a broad plain-like surface relief. New systems of streams then developed and new outpourings of lava came, resulting in the formation of intervolcanic streams the gravel deposits of which now lie intercalated with the volcanic rocks. The courses of the ancient streams which ran westward somewhat resembled in general direction the streams which are flowing there today, though the positions of their courses differ greatly. One northern early Tertiary stream channel, however, known to geologists as the old Jura River now lies at right angles to the present major drainage system. Its old course now stands deformed, rising and falling in a peculiar manner. The cutting down of the more recent streams has formed deep canyons in bedrock, while remnants of the Tertiary river gravels have been left high above, on the crests of the intervening ridges.

The last period in the geologic history of California is quite as eventful as any previous period. In the earliest Quaternary or in the latest part of the Pliocene, the Sierra Nevada may be pictured first as a mountain range, not half so high as it is now, with the main streams flowing westward through broad mountain valleys while tributaries entered from southeast and northwest directions following along courses which once marked the trend of the old Cretaceous structure. Then, as the Quaternary proceeded, the mountain range was upheaved by a succession of movements to a great altitude. It was tilted southwestward, breaking along faults that traversed its eastern side, becoming displaced from the adjoining more depressed Great Basin area and forming a series of prominent east-slope scarps. In several places the eastern front of the Sierra Nevada is today a spectacular topographic as well as structural feature.

Those streams, the courses of which were directed westward down the slope of the newly tilted block, were thus enormously accelerated so that they cut very deep and rugged canyons, though the remaining intervening ridges, when viewed from above or along their edges appear as a nearly level plain or as a low, broad, undulating surface tilted slightly westward. The period of canyon-cutting was especially effective in the southern Sierra Nevada, for example, in the Yosemite Valley and Kings River Canyon. The tributary streams of these major canyons, running in a longitudinal direction to the range as a whole, did not

have their beds so tilted nor their water-flow so accelerated; thus they were left "hanging" high above the bottom of the newly-made canyons and have been obliged to pitch into the latter often by a series of high waterfalls. The Quaternary upheaval of the Sierra Nevada thus caused such drastic stream adjustment that the old Tertiary drainage system was completely discarded. The new rivers even cut through the lavas and underlying channels that had been entombed since the Miocene volcanic activity.

In the higher Sierra, snow accumulated and glaciers crept down the valleys for a short way, modifying their stream-cut V-shape to U-shaped troughs. Such is the case of Yosemite Valley. Morainal deposits were formed and little lakes were left as the ice retreated. Outwash streams, derived from the melting glaciers, built gravel bars at the foot of the mountains, where the streams entered the Great Valley.

The closing of the period of glaciation brings us to the present surface form of the mountains.

MOTHER LODE BELT

Lying in a general northwest-southeast direction in the central foothill region of the Sierra Nevada, is a strip of country, about one mile wide by 120 miles long, which is one of the most famous gold-mining districts of the world—the Mother Lode belt. Mining started in 1849 near its south end and has continued to the present day. The deepest gold mines of North America are in this region and reach depths of nearly a mile, vertically from the surface. To the end of 1931 the total gold output amounted to about $225,000,000, one-half of this coming from a ten-mile portion of the belt from Plymouth to Jackson.

In the pioneer days it was thought that the Mother Lode was one continuous vein, the sharp ridges of white quartz marking its course. Now it is known that the Mother Lode is a belt or system of quartz veins which carry varying amounts of gold. They all occur in a more or less fissured zone of faulting (specifically a zone of reverse faulting) and are not continuous.

The ores were deposited at the end of the great period of igneous intrusion, and since that time combined upheaval of the range plus erosion has brought the veins to the surface or comparatively near to it. Many gold-bearing veins were completely eroded away. The origin of the gold, found in the veins, is believed to be from deep-seated sources, associated with the intrusive magmas that have solidified to form the igneous rocks which are now exposed through long-continued erosion. Some of the gold, however, may also have been derived from the intruded rocks, and carried in solution by water to points of concentration. For the most part the gold ores are of low or moderate grade.

The gold-laden quartz veins are not confined to the Mother Lode belt. Paralleling it on either side and lying farther to the north of it are other systems of veins and other kinds of mineral deposits. For the most part these are also genetically related to the disturbances and internal activities that accompanied or followed the period of widespread late-Jurassic igneous intrusion.

Photograph by courtesy of G. E. Russell.

FIG. 5. Airplane view of Yosemite Valley and Half Dome, looking to the north with the snow-capped even-crest line of the High Sierra in the distance. The higher and more rugged character of the southern Sierra Nevada is thus contrasted with the northern (Figures 3 and 4). The western slope is cut by mighty canyons, the upper courses of which have been reshaped by Pleistocene glaciers.

TERTIARY RIVER CHANNELS

The first extensive erosion that brought the Sierra Nevada down to a region of moderate relief was in Cretaceous time. Sand and gravel were washed to the sea, which then occupied the position of the Great Valley, and were deposited in a thick series of marine sandstones and conglomerates. No appreciable amount of gold was gathered and concentrated at this time.

Later, during the Tertiary, as the mountain range was gradually raised and tilted westward, streams coursed down the mountain flanks and deposited white quartz gravels carrying much gold. It was from the gold-bearing quartz veins and other gold-impregnated rocks brought to light during Cretaceous erosion, that these Eocene streams first gathered their wealth and concentrated it in their channels.

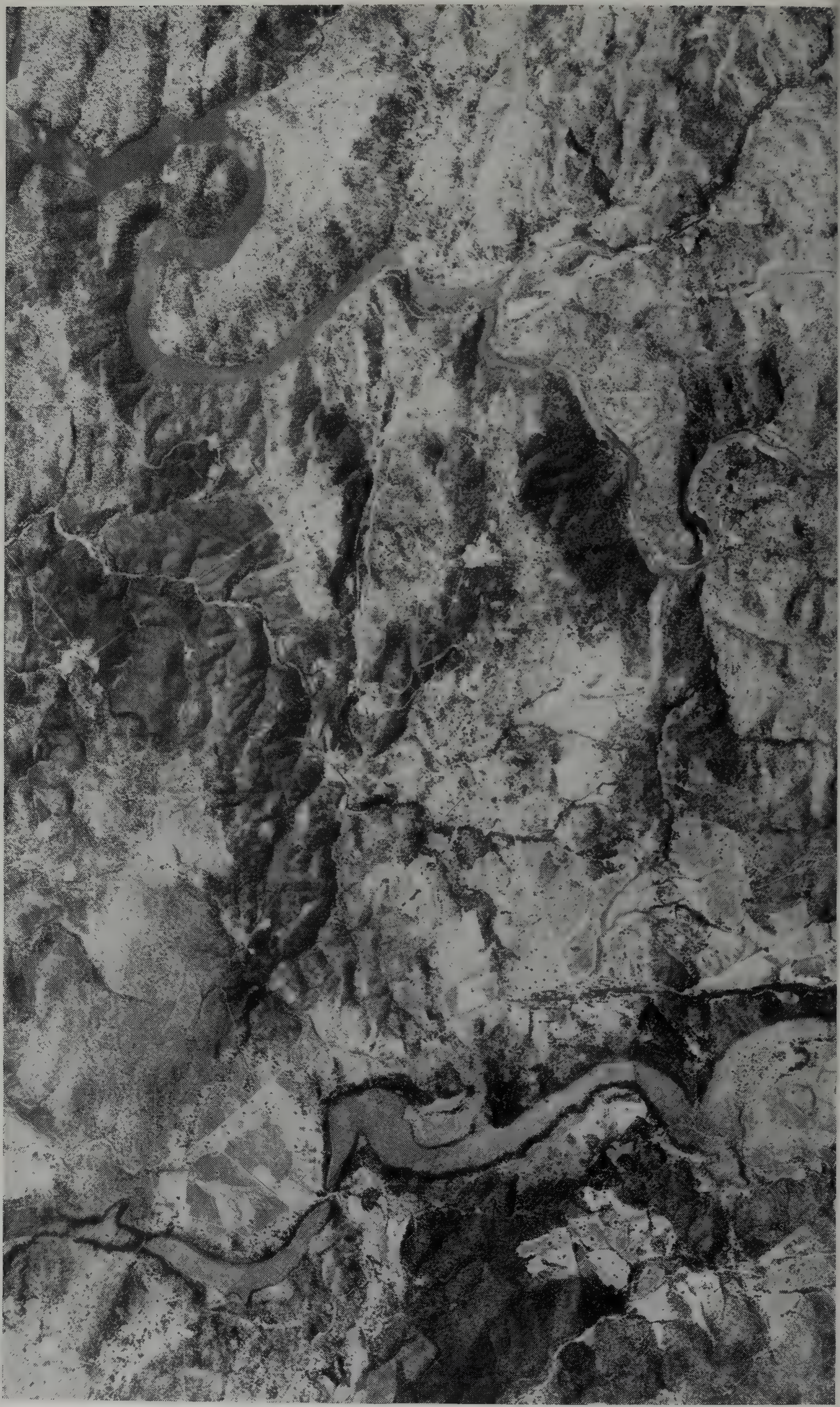
The Eocene quartz gravels were then buried by Miocene lavas and new systems of streams were developed; many of these were also buried by volcanic extrusions. Boulders of volcanic rock, tuff, and breccia are to be found in the intervolcanic stream deposits. Except where these streams eroded through the lava beds and washed out the gold from the older white gravels, they are barren of gold values.

The westward tilting of the Sierra Nevada progressed throughout the Tertiary and Quaternary ages. The old Eocene surface and its systems of streams were tilted along with the mountain block so that they now slope westward more steeply than they did during the time when these ancient river courses drained the area. The present streams have now cut through this older surface, cutting deeper canyons toward the east where the older surface now stands highest. Therefore, the steeper-sloping older surface, now to be seen along the intervening crests, converges westward to meet the present slope of the mountain valleys as it flattens out towards the Great Valley. The Tertiary gravel deposits for this reason are found at increasingly higher altitudes eastward and on ridge crests far above the present rivers.

On the geologic map the positions of the principal Tertiary stream courses are shown. The data for this have been drawn principally from reports issued by the U. S. Geological Survey and listed in this paper. The names of the geologists preëminent in this particular study of the Tertiary channels are listed as follows: J. D. Whitney, J. S. Diller, H. W. Turner, and Waldemar Lindgren.

It must be understood, however, that the geologic record on which this interpretation is based is only fragmental at the best. Many Tertiary channels have undoubtedly been omitted and others which are shown may be somewhat inaccurately located or in part nonexistent.

It has been estimated that the Tertiary gravels have produced $300,000,000 in gold but that $600,000,000 worth still remains. This last estimate, however, may be rather high, and the gold content of the gravel is for the most part of low grade. Hydraulic mining was responsible for the extraction of most of this Tertiary placer gold, but since the court injunctions of 1884, which restricted the dumping of the vast amounts of gravel tailings into the present streams, this great industry has all but ceased.



Photograph by courtesy of Fairchild Aerial Surveys, Inc.

FIG. 6. Aerial map, a mosaic of vertical photographs, of a region, 6½ x 4 miles in size, lying between Sonora and Angel's Camp, showing the meandering shape of both Table Mountain, a lava flow which entombed an ancient Tertiary stream channel, and Stanislaus River, which is partly flooded by an artificial dam.

FIG. 7. Geologic map, which may serve as an index, of the area shown in Fig. 6. Surveyed in 1898 by Becker and Ransome, and reprinted from U. S. G. S. Folio 63 in Prof. Paper 157, Pl. 2. The squares indicate sections. The geological formations are shown by patterns, with symbols as follows: Pgv, auriferous river gravel; Jm, Mariposa formation; Cc, Calaveras formation; ls, limestone; Nl, latite; Nat, andesite tuff; mdi, metadiorite; sp, serpentine; ma, meta-andesite; ams, amphibolite schist.

The well-recognized major drainage system of the Tertiary may be listed as follows:

Jura River, which rose in the high Sierra, flowed for 50 miles in a direction a little west of north. Its terminus is now concealed under the lava which covers the northern end of this great mountain range;

Photograph by courtesy of Fairchild Aerial Surveys, Inc.

FIG. 8. Vertical airplane view, showing in greater detail the point at which the Table Mountain lava flow crosses the Mother Lode.

but it is thought that this ancient stream entered at this point a large body of water.

Magalia Channel, of minor extent, located northeast of Chico.

Tertiary Yuba River, located in the same general region as the present Yuba River.

Tertiary American River, located in the same general region as the present American River and its three main forks. In this region is also located the Intervolcanic American River.

Tertiary Mokelumne River, located in the general district of the Cosumnes and upper Mokelumne rivers.

Tertiary Calaveras River, located in general region of the Mokelumne, Calaveras, and South Fork of the Stanislaus rivers. Along the latter is also located the course of the Intervolcanic Cataract Channel.

Tertiary Tuolumne River, which follows the same general trend of the present Tuolumne River.

QUATERNARY GRAVELS

Since Tertiary time, the streams of the Quaternary period, including those of today, have rewashed and reconcentrated the gold carried from the older channels. To this store have been added new particles of gold, washed from the original quartz veins of the bedrock. It is interesting to note that the discovery of gold in California by John Marshall, January 24, 1848, was made in the recent stream gravels of the South Fork of the American River, near Coloma, El Dorado County.

It has been estimated that some $900,000,000 in gold values have been extracted from Quaternary gravels. Today large dredges are still working in the old alluvial cones, formed in part by recent stream deposition and in part by the outwash of glacial streams which, after a torrential course down the canyons of the Sierra Nevada, deposited their loads along the border of the Great Valley.

List of Gold Mines and Districts as Shown by Numbers on Geologic Map of Northern Sierra Nevada

No.	*Name of mine or district*	*Quartz*	*Placer*	*Dredge*
	MARIPOSA COUNTY			
1	Princeton Mine	x	–	–
2	Josephine Mine	x	–	–
3	Virginia Mine	x	–	–
	TUOLUMNE COUNTY			
4	Eagle Shawmut Mine	x	–	–
5	App-Heslep Mine	x	–	–
6	Rawhide Mine	x	–	–
7	Confidence Mine	x	–	–
	CALAVERAS COUNTY			
8	Carson Hill Mine (Melones Mine)	x	–	–
9	Utica Mine	x	–	–
10	Sheep Ranch Mine	x	–	–
11	Gwin Mine	x	–	–
	AMADOR COUNTY			
12	Argonaut and Kennedy Mines	x	–	–
13	Central Eureka Mine	x	–	–
14	Keystone Mine	x	–	–
15	Bunker Hill Mine	x	–	–
16	Plymouth Mine	x	–	–
	EL DORADO COUNTY			
17	Church Union Mine	x	–	–
18	Kelsey Mine	x	–	–
	PLACER COUNTY			
19	Forest Hill District	–	x	–
20	Iowa Hill District	–	x	–
21	Dutch Flat District	–	x	–

	NEVADA COUNTY			
22	Allison Ranch Mine	x	–	–
23	North Star Mine	x	–	–
24	Empire Mine	x	–	–
25	Idaho Maryland Mine	x	–	–
26	Empress (Newtown) Mine	x	–	–
27	Champion Mine	x	–	–
28	Hoge Mine	x	–	–
29	Murchie Mine	x	–	–
30	Relief Hill District	–	x	–
31	North Bloomfield District	–	x	–
	SIERRA COUNTY			
32	Sixteen-to-One Mine	x	–	–
33	Forest City District	–	x	–
34	Brush Creek Mine	x	–	–
35	Sierra Buttes Mine	x	–	–
36	Howland Flat District	–	x	–
	PLUMAS COUNTY			
37	Bellevue Mine	–	x	–
38	Plumas Eureka Mine	x	–	–
	BUTTE COUNTY			
39	Cherokee Mine	–	x	–
40	Magalia Mine	–	x	–
41	Genii Mine	–	x	–
42	Oroville District	–	–	x
	YUBA COUNTY			
43	Yuba River District	–	–	x
	SACRAMENTO COUNTY			
44	Folsom District	–	–	x
	STANISLAUS COUNTY			
45	La Grange District	–	–	x

NOTES ON OCCURRENCE AND AGE OF FOSSIL PLANTS FOUND IN THE AURIFEROUS GRAVELS OF SIERRA NEVADA

By Ralph W. Chaney [1]

INTRODUCTION

The first comprehensive study of the fossil plants of the Auriferous Gravels of the Sierra Nevada, California, was made by Lesquereux and published in 1878.[2] Many years later Lesquereux's type specimens were examined by Knowlton, who in 1911, revised the descriptions of them in connection with his own study of additional fossil material.[3] Few collections have been made subsequently until the past ten years, during which several new and critical fossil localities have been discovered. At the present time, the floras from these and certain of the old localities are receiving detailed study by the writer and his associates at the University of California. This statement is written for the purpose of placing on record the location and approximate age of the floras of the Auriferous Gravels as now known. It is hoped that the present mining activity on the west slope of the Sierra Nevada may result in the discovery of additional material which may be placed at our disposal for study.

While the floras of the Auriferous Gravels have commonly been considered of Miocene age on the basis of Knowlton's studies, it has been apparent for a number of years that some of them are older; Knowlton himself considered the possibility that certain of the floras which occur in gold-bearing gravels are as old as Eocene.[4] Our studies in recent years definitely establish the fact that the term *Auriferous Gravels* can not properly be applied as indicating a definite stratigraphic unit, since the floras range in age from Eocene to Miocene.

The statement which follows, in which the floras are considered separately on the basis of their occurrence, includes suggestions regarding their age and the physical conditions under which they lived.

FOSSIL LOCALITIES [5]

Locality 92. Buchanan Tunnel, Table Mountain, Tuolumne County.

Leaf impressions occur in the tuffaceous shale at the roof of the tunnel, a total of 14 species being represented. Of these, 12 have been previously recorded in Miocene deposits elsewhere in the State and in Oregon, Washington, Idaho and Nevada.[6] Teeth of *Hipparion* (extinct species of ass) have been found in associated gravels in the Springfield Mine. The upper Miocene age of these deposits seems clearly established. The flora assemblage indicates a climate characterized by temperature not unlike that in the region today, and by a slightly higher

[1] Chairman, Department of Paleontology, University of California, and Research Associate, Carnegie Institution of Washington.

[2] Mus. Comp. Zool. Mem., vol. 6, No. 2, 1878, pp. 1–62, pl. 1–10.

[3] In Lindgren, U. S. Geol. Surv. Prof. Paper 73, 1911, pp. 57–64.

[4] *Op. cit.*, p. 61 and p. 63.

[5] Locality numbers (also shown on Geologic Map of Northern Sierra Nevada prepared by Olaf P. Jenkins, and appearing in this issue of Mining in California) refer to collections in the University of California.

[6] Chaney, Carn. Inst. Wash., Pub. 349, 1925, p. 33.

rainfall. The forest represented by these fossils appears to have occupied a valley at low or medium elevations.

Locality 204. Oakvale Mine, Nevada County.

All the leaves were secured from shale in the mine tunnels. About 10 species are represented, of which several are especially characteristic of the Miocene of the John Day Basin, Oregon, and elsewhere in western America. The floral composition differs somewhat from that at the Buchanan Tunnel, suggesting a slightly cooler and dryer climate, like that in eastern Oregon during the Miocene.

Locality 208. La Porte Mine, Plumas County.

About three-quarters of a mile north of La Porte, below the cliff exposed by hydraulic operations in the La Porte Mine, numerous blocks of tuff fallen from a ledge above contain well-preserved fossil leaves. They are of types wholly unlike those at the preceding localities, and also differ in most respects from the floras considered below. It is clear that they represent trees which lived in a much warmer and more humid climate than was prevalent during the Miocene. Too little is known of the Oligocene floras of western America to make comparisons with them reliable; it is clear, however, that the La Porte flora is older than the Miocene, and that it is referable to the Oligocene or upper Eocene, in which representatives of some of the genera are known to occur.*

Locality 42. Iowa Hill, Placer County.

Knowlton listed 54 species as occurring at this locality.[7] Additional material collected by the writer is as yet incompletely studied. The composition of the flora is much like that from Chalk Bluffs as described below, and there is no present basis for assuming any difference in age.

Locality 104. Buckeye Flat, Nevada County.

It may be supposed that this is the same locality as that designated by Lesquereux and Knowlton as Chalk Bluffs, since the nature of the matrix and the fossil species is the same in the recent collections as in those of these earlier paleobotanists. The fossil leaves occur in pipeclay in a small gully on the north side of an abandoned hydraulic mine. More than 30 species have been recognized, several of which are especially characteristic of the middle to upper Eocene floras of northern California, Oregon and Washington. Most of the genera are no longer represented in the modern flora of the United States, and their representatives in Mexico and Central America live under subtropical conditions. A similar assemblage of plants requiring a warm, moist climate has been recorded from Eocene horizons in other parts of North America and in Europe.

---

* Since these fossil-beds in tuff lie on top of the auriferous quartz gravel beds below, the age of the latter would be older than the tuff. (Note by O. P. Jenkins.)

[7] *Op. cit.*, p. 62.

Locality 206. Cherokee Mine, Butte County.

In clays associated with the quartz gravels, 12 miles north of Oroville, fragmentary leaves have been collected, which suggest that these deposits belong to the lower Eocene.[8] Present information is inadequate to describe fully the conditions under which these plants lived, but they may be considered to have occupied a region in which the temperature and moisture developed a subtropical type of vegetation.

Locality, 7½ miles southwest of Susanville, Lassen County.

This locality has not yet been visited by the writer, but the material collected from it has a typical Eocene aspect, and the age of the deposits can be referred with little question to the lower Eocene.[9]

SUMMARY

The tuffs and shales in which fossil plants occur interbedded in the Auriferous Gravels range in age from lowermost Eocene to upper Miocene. During this time, there was a climatic trend from subtropical to temperate conditions, which resulted in the elimination of palms and other large-leafed species and the incoming of types of plants similar, in general, to those now living in North America. The Miocene flora indicating a temperate climate, includes genera no longer living in western America, although they occur in eastern America and eastern Asia. The evidences of difference in living conditions in the Eocene and the Miocene make it possible readily to differentiate between the older and the younger floras of the Auriferous Gravels.

[8] See Allen, V. T. The Ione Formation of California. Univ. Calif. Pub., Bull. Dept. Geol., vol. 18, 1929, pp. 400–401.
[9] Knowlton, *op. cit.*, pp. 60–61.

Photograph by Susan Potbury.

FIG. 1. Hydraulic workings, La Porte Mine, where fossil leaves were collected (Locality 204). a. Soil, etc. b. Conglomerate. c. Weathered tuff, nodular. d. Tuff, with fossil wood and broken leaves; d′ contains well preserved leaves. e. Lignitic interbeds. h. Contact zone, covered by fine gravels and tuff. f. White quartz gravels, auriferous (without tuff beds). Geologic section by Mary Balch.

FIG. 2. Fossil leaf impression of a Miocene black oak (*Quercus pseudo-lyrata*), from the Oakvale Mine, University of California Locality No. 204. This is an index marker for the Miocene.

GLACIAL AND ASSOCIATED STREAM DEPOSITS OF THE SIERRA NEVADA

By Eliot Blackwelder [1]

FORMER DISTRIBUTION OF GLACIERS IN THE RANGE

At present the Sierra Nevada harbors a few tiny glaciers, all of which lie in deep recesses on the slopes of high peaks, such as Mt. Lyell and Mt. Dana. In the colder epochs of the Pleistocene period, however, the snow line was much lower, the excess of snowfall over melting much greater and hence great fields of perennial snow accumulated in the higher part of the range. From the compaction of these snow fields long tongues of ice crept down many of the valleys. All the great canyons in the Sierra contained such glaciers, the largest of them (the Tuolumne glacier) 3000 feet thick, 2 to 5 miles wide, and 40 to 50 miles long. Their snouts reached elevations of 4000 feet or less. In a few cases they descended to about 2500 feet above sea level or even lower. In the smaller valleys and among the lower mountains only short and weak glaciers developed. To find glaciers today as large as those which once occupied the canyons of the Tuolumne and Merced, one would have to go to the St. Elias and Alaskan ranges.

Owing to the greater aridity and shortness of the canyons on the east slope of the Sierra, the glaciers there were smaller. As examples, the West Walker glacier was about 26 miles long and the Truckee glacier only 9 miles.

DEPOSITS DUE TO GLACIATION

During the thousands of years in which the cold climate held sway, the glaciers swept away the accumulated soil and talus in the mountain valleys. To some extent they rasped the bedrock, rounding off projecting angles and leaving the rocky bed grooved and scratched. In favorable situations they also quarried out loose blocks of the bedrock and dragged them on down the valley.

Glaciers descend well into the zone where melting is dominant over freezing. As the lower parts of the glaciers waste away, copious streams are formed. These streams sweep away much of the debris which the glaciers bring down. The supply of such material is so great that glacial streams are normally overloaded. They are choked with gravel and therefore build up the bottoms of the canyons to depths of 50–100 feet, forming long winding flats.

The glacial debris which is not removed by the river lodges around the end of the glacier and along its sides, thus building a moraine. The moraines are now found as confused bouldery ridges, hills and terraces ranging in size from obscure features only a few feet high, hidden in the forest, to great embankments and dump piles 500–1000 feet high. The small ones are well exemplified by those in Yosemite

[1] Professor of Geology, Stanford University, California.

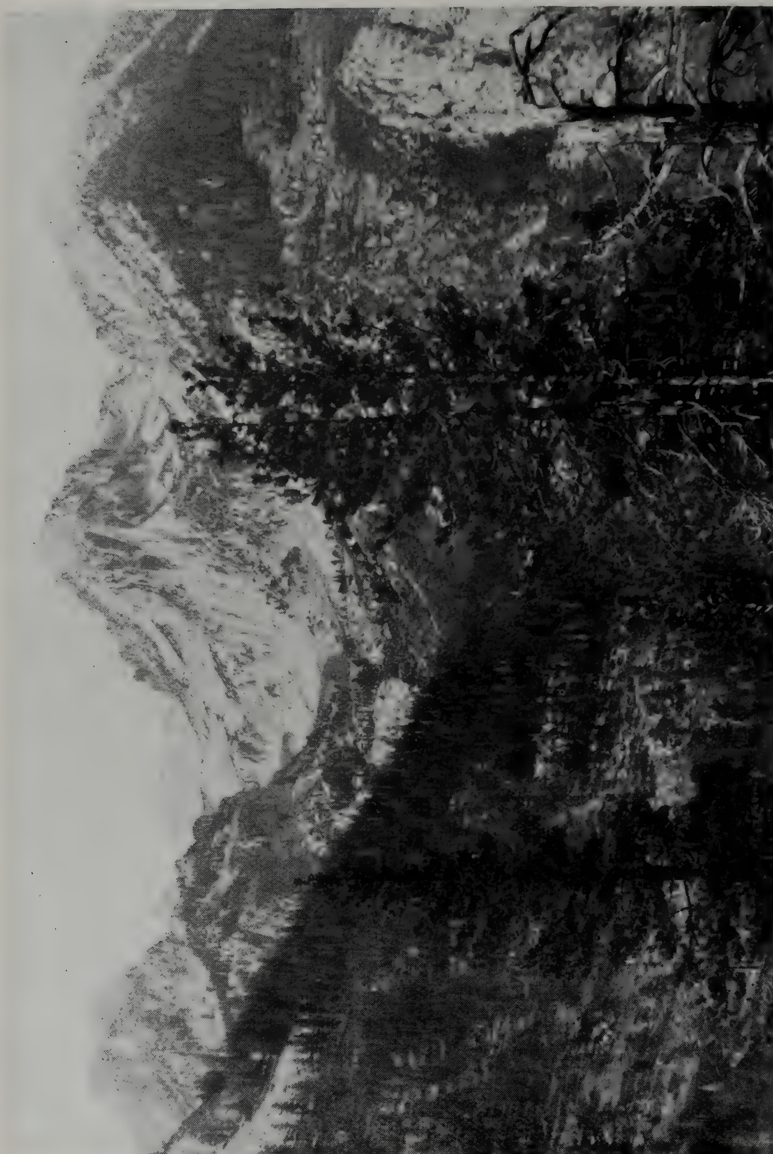


FIG. 1. Photograph of a glaciated valley, showing the round-bottomed form of the canyon and the sharply serrate peaks which projected above the ice. Blacksmith Canyon, southwest of Bridgeport.

FIG. 2. A lateral moraine. One of a pair of boundary ridges marking the edge of the glacier which once occupied McGee Canyon on the east side of the Sierra Nevada.

Valley and the large ones by such bulky moraines as one sees west of Bishop, near Convict Lake, and west of Mono Lake.

As the glacial climate began to wane, the ends of the glaciers were slowly melted back, leaving hollows behind the moraines. Most of these basins held lakes, such as Fallen Leaf and June Lakes. Rivers from the ends of the glaciers swept large quantities of gravel and sand into the lakes, thus building deltas. Many of the lakes were eventually filled in this way, leaving such plains as the floor of Yosemite Valley.

The streams which issue from lakes are clear and therefore not overloaded. For that reason they require a gentler gradient and hence cut down into the gravel deposits which the overloaded glacial rivers had formed in the canyons below the moraines. Such trenching left remnants of the old gravel flats as terraces now 20–75 feet high.

HOW TO DISTINGUISH THE SEVERAL TYPES OF DEPOSIT

The deposits left by glaciers should be distinguished from those made by streams, lakes and other agencies.

The ice tongue of a glacier leaves only one type of deposit, called *till.* It is wholly unstratified and its components are quite unsorted—a jumbled orderless mass of clay, sand, and boulders. Blocks three to five feet in diameter are common and those 25 feet or more are not rare. In general, the size of such boulders depends upon the spacing of the joint-cracks in the rocks of the mountain sides. Usually till is an earthy mass well sprinkled with stones and boulders but in some cases the boulders predominate. This is particularly true of the deposits of small glaciers which have done little more than sweep the coarse talus from the valley slopes. The stones in till may be of any shape from well-rounded to angular but many have the corners and edges rounded. It is usual to find some that have been bevelled by being rasped along the bottom of the glacier. Hard rocks may thus be well polished. Such stones, like the bedrock, are covered with scratches which are easily recognized.

It is often difficult to identify till, especially if it has been much decayed or eroded or is poorly exposed. It may then be confused with other bouldery deposits which are unstratified. From volcanic mud-flow deposits, such as abound in the Miocene beds on the Sierra Nevada flanks, till may often be distinguished by its containing large quantities of nonvolcanic rocks. Even this criterion fails where glaciers occupied volcanic mountains such as Mts. Shasta and Rainier. Ordinary mud-flow deposits are seldom as thick as glacial moraines and are generally interbedded with typical stream gravel and sand, as in the alluvial fans of the arid regions. Unless the surface topography is still preserved or unless one finds plenty of scratched stones, it may be almost impossible to distinguish till from landslide dumps. In many cases no one type of evidence can be relied on, but one must study all the facts and weigh the importance of each.

The rivers which issue from glaciers deposit coarse gravel, then fine gravel, and finally sand as the current weakens near the edge of the mountains. These three grades of detritus are more or less interbedded, because variations in the river's power occur from time to time at a given place. Like river deposits in general, those of glacial streams are distinctly stratified, though usually cross-bedded. They

are fairly well sorted into separate layers of sand and gravel of various sizes. The pebbles are normally well rounded and very rarely either faceted or scratched. Angular stones are rare. Although small boulders are carried by ice cakes and become stranded in the glacial river gravel, large boulders are generally absent.

To distinguish the deposits of a glacial from a nonglacial river is difficult and often impossible, unless one can trace the gravel terraces into actual connection with a glacial moraine or can work out in detail the physiographic history of the district.

The deposits made in glacial lakes are rather distinctive. On the bottom of the lake, clay and silt are laid down very evenly in thin sheets which are commonly banded as seen later in cross-section. This is due to the fact that the layer deposited in winter is finer and darker

FIG. 3. A typical glacial deposit, known as *till*, exposed in a road-cut. The wide variation in size of the components of the deposit and the complete lack of stratification are characteristic.

in color than the one laid down during the summer melting season. Unlike most lake deposits the glacial lake clays commonly contain scattered pebbles and even small boulders which have been dropped from cakes of ice floating over the lake. These laminated clays may be associated with beds of peat or chalky or diatomaceous earth formed by organisms that inhabited the clearer parts of the lake. Streams entering the lake form advancing deltas composed of gravel and sand in which the stratification is characteristic of deltas in general. In quantity the delta deposits often exceed the other lake deposits greatly, for the glacial rivers carry large quantities of coarse detritus all of which lodges in the deltas rather than upon the floor of the lake.

Other deposits that may be formed in glacial valleys, such as landslides, talus, and alluvial fans, need not be described specifically. They are local and generally well known.

Photograph by courtesy of G. E. Russell.

FIG. 4. Airplane view, looking north up the Kern River, showing its glaciated valley surrounded by a vast number of peaks and cirques of the High Sierra.

HISTORY OF GLACIATION IN THE SIERRA NEVADA

One can not understand the glacial geology of the range without knowing something of the sequence of events. The Pleistocene period consisted not of one cold climatic period but of several long epochs in which conditions were much like those of today alternating with shorter epochs of cold during which glaciers developed. At least four and perhaps five such glacial epochs occurred. They are locally called, beginning with the oldest, the McGee, the Sherwin, the Tahoe, and the Tioga. All were in the Pleistocene period. There is no record of glaciers on the Pacific slope during Tertiary times.

The Tioga glacial epoch ended only 10,000–15,000 years ago, and hence its moraines and other features are almost as fresh as if made in modern times. The deposits of the next older, or Tahoe, epoch are notably decayed and eroded but still easily recognized. On the whole they were larger and bulkier than those of the latest epoch. The still older glacial deposits have been so deeply decayed and so extensively eroded that they are generally difficult to recognize at all. Very rarely are the moraines clearly identifiable and even the till itself is hard to distinguish from decayed granite or old mudflow deposits. When reference is made to glacial features of the Sierra Nevada those of the last two epochs are usually meant. In another paper [2] I have described at length the means of distinguishing the various stages of glaciation.

So far as now known, the older glaciers were of larger size than the later ones. For example, in the Merced Valley the glacier of the second epoch was about 38 miles long, that of the third epoch about 32 miles and that of the last epoch only 20 miles. In the valley of Rock Creek northwest of Bishop the corresponding dimensions were 17, 14, and 11 miles. The deposits of the first stage have been so greatly eroded that almost nothing is known of their extent and they have been recognized only near Convict Lake and the West Walker Valley on the eastern slope of the range.

EFFECT OF GLACIATION UPON PLACER GOLD DEPOSITS

Since it is the habit of a glacier to scrape off loose debris and soil but not to sort it at all, ice is wholly ineffective as an agency of concentration for metals. Gold derived from the outcrops of small veins is thus mixed with large masses of barren earth. Attempts to mine gold in glacial moraines, where bits of rich but widely scattered float have been found, are for that reason foredoomed to failure.

If a glacier advances down a valley which already contains gold-bearing river gravel, it is apt to gouge out the entire mass, mix it with much other debris and deposit it later as useless till. Under some circumstances, however, it merely slides over the gravel and buries it with till without disturbing it.

On the other hand, the streams born of glaciers or slowly consuming their moraines have the power to winnow the particles of rock and mineral matter according to size and heaviness. Such streams may form gold placer deposits in the well-known way by churning the load they carry and allowing the heavy minerals to sink to the bedrock. Placers may therefore be found in the deposits of glacial rivers if

---

[2] Blackwelder, Eliot, Pleistocene glaciation in the Sierra Nevada and Basin Ranges: Geol. Soc. America Bull., vol. 42, pp. 865–922, 1931.

there are gold veins exposed in the glaciated area upstream. Nearly all the gravel which has been dredged for gold along the foothills of the Sierra Nevada was deposited by rivers derived in part from glaciers along the crest of the range, but most of the gold was probably picked up in the lower courses of such rivers. Since glacial rivers choke themselves and build up their channels progressively, their deposits are

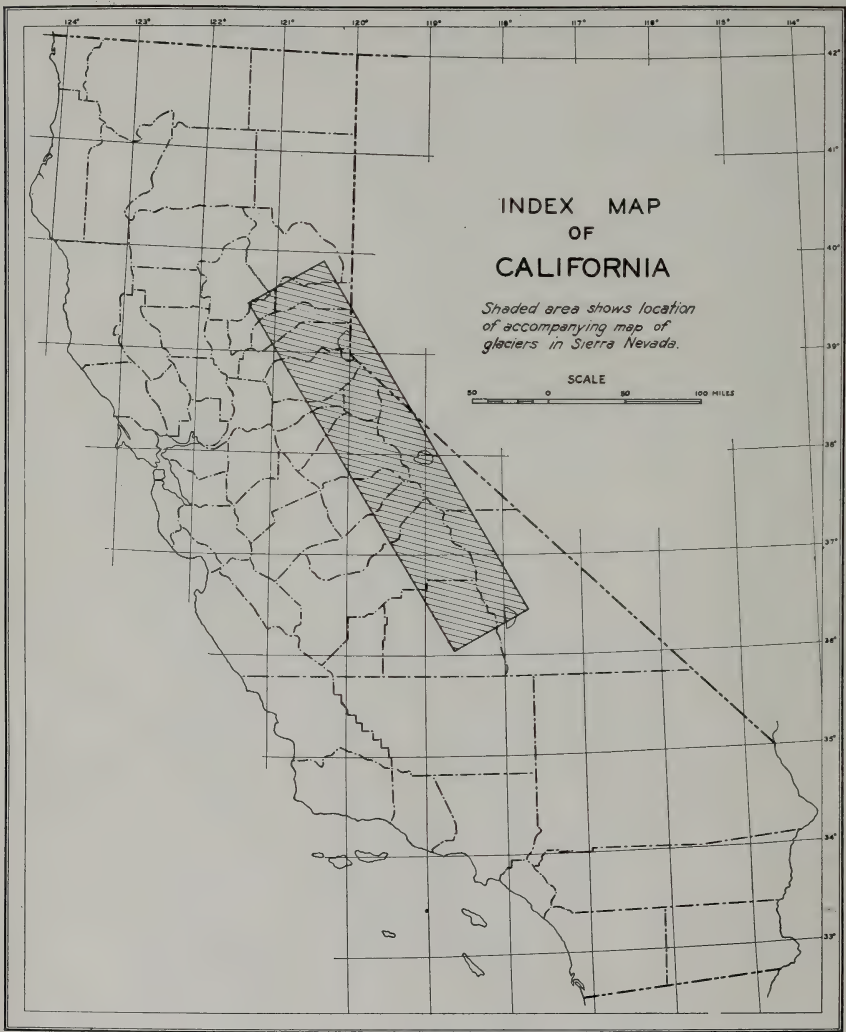


FIG. 5.

likely to be thicker and not so well concentrated as those of the more normal graded rivers which are not associated with glaciers. Perhaps this explains in part the fact that most of the great placer gold deposits of the world, including those in Siberia, the Klondike, Central Alaska and the Ural Mountains, are not in glaciated regions, although they have in part been formed by melt-water from glaciers many miles away.

PLATE II

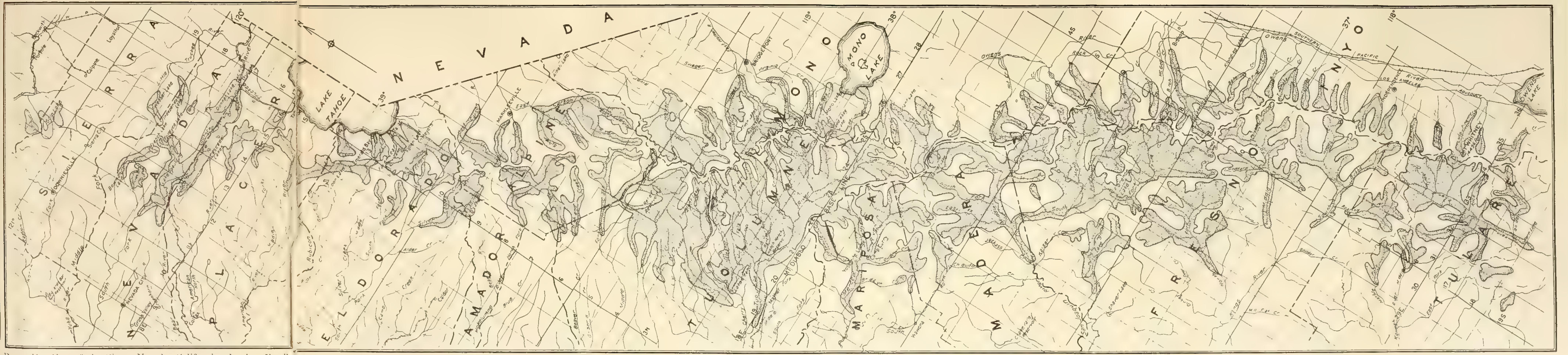


PLATE II. Map of the Sierra Nevada, California, showing distribution of glaciers in late Pleistocene time, prepared by Eliot Blackwelder, August, 1932. (*Base map after U. S. G. S.*) The dimensions of the glaciers of the third (Tahoe) glacial epoch are indicated by the stippled areas. Outside of certain areas which have been studied in detail, the mapping should be considered only tentative. Scale of map, approximately 12 miles to the inch.

JURASSIC AND CRETACEOUS DIVISIONS IN THE KNOXVILLE-SHASTA SUCCESSION OF CALIFORNIA

By Frank M. Anderson [1]

OUTLINE OF REPORT

ABSTRACT

The geologic age of the Knoxville-Shasta stratigraphic succession of sediments in the Coast Ranges of California, found to be nearly 27,000 feet in thickness, has troubled both geologists and paleontologists since the early descriptions of its several parts were published. Although some considered that this succession included beds that were later Jurassic in age, others thought the entire body should be assigned wholly to the Cretaceous system, because of the apparent continuity of its dispositional sequence.

It is the purpose of this paper to point out the distinctness in age of the two parts and to show that the Knoxville belongs to the Jurassic, while the Shasta group is of Cretaceous age. The line of demarkation between them is indicated. Furthermore, the paper should serve as a starting point for subsequent work upon later Cretaceous deposits.

It is also shown in this report that the lower portion of this succession, which is assigned to the upper Jurassic, has a greater thickness than any other known Jurassic sequence of equivalent age found elsewhere on the Pacific coast. On the other hand, the upper part of the succession, 12,540 feet in thickness, known as the Shasta group, is definitely lower Cretaceous, and includes at its base the lowest beds assignable to this system. Upon stratigraphic grounds alone it may be inferred that the older part of the entire succession must be pre-Cretaceous in age, and therefore Jurassic.

The possible future economic features of the Knoxville-Shasta succession is indicated at the close of this paper. Quicksilver deposits in places are associated with the beds where they are in contact with igneous rocks. In places the conglomerates have been found to contain some gold. It is suggested that the more

[1] Honorary Curator of Paleontology, California Academy of Sciences, Golden Gate Park, San Francisco, California.

calcareous beds of the formation may prove to be natural cement rock. The occurrence in some localities of small amounts of petroleum in the sediments may some day lead to the discovery of commercial deposits of oil.

INTRODUCTION

For more than 40 years, the question of the stratigraphic and faunal relations of the Knoxville and Shasta groups in the later

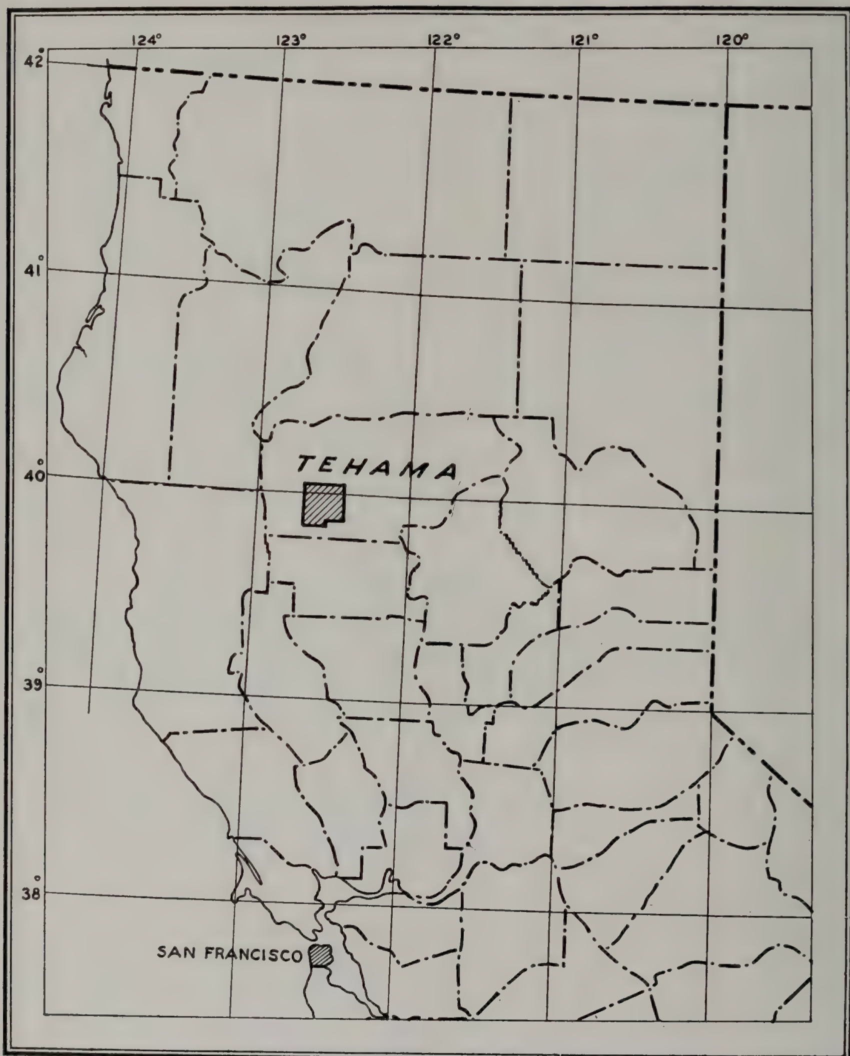


FIG. 1. Index map of northern California, showing location of Tehama County and the accompanying geological sketch map.

Mesozoic of the California Coast Ranges has been much discussed, but has still remained unsettled. A recent return to the subject, and a review of the literature, has led to a re-examination of some of the more complete and representative sections across the great body of Mesozoic

strata found on the eastern flanks of these ranges west of the Great Valley, both north and south of San Francisco Bay.

The results of these examinations have made it necessary to revise some of the earlier conceptions regarding this succession, its several units, and their geological relations, not all of which were based upon field work. A brief résumé of recent results is here offered.

In the area between Elder Creek and Toms Creek, southwestern Tehama County, all of the beds included in this succession are well exposed, as was first shown by Diller,[2] and later discussed by Diller and Stanton,[3] in the early nineties. It is this area that has been especially studied in the recent work, and is illustrated by the sketch map, profile and section herein contained. It is regrettable that no accurate base map of this area exists, and that the sketch here included is, therefore, imperfect.

The late Mesozoic marine beds in the foothills of this district have a total thickness of about 27,000 feet, without including any of the later Cretaceous (Chico) beds, and perhaps not all of the upper part of the beds immediately underlying. As will be seen later, this immense succession includes strata belonging to two distinct systems, Jurassic and Cretaceous, corresponding to the Knoxville and Shasta groups as they were originally defined by their respective authors. The divisions herein proposed, therefore, are not new, but represent a return to the early definitions, which should not be forgotten, since they harmonize admirably with those long recognized in the standard Mesozoic column of Europe, where such deposits have been more exhaustively studied.

No conspicuous stratigraphic break is found locally in the entire Knoxville-Shasta succession, and for this reason its subdivision, as here represented, was not thought possible by the earlier writers. A more extensive search for diagnostic fossils, and fossil horizons, not only in this particular area, but in neighboring districts, affords a more satisfactory basis for an analysis of the deposits. Also a preliminary study of the geographic distribution of the several units recognized lends support to confidence in the correctness of the views expressed in this paper.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the services of Messrs. A. I. Gregersen and R. W. Burger of The Texas Company in measuring sections and collecting samples. Cooperation and assistance was also received during the field examinations by the Geologic Branch of the California State Division of Mines. The California Academy of Sciences also cooperated not only in the field work, but has supplied facilities for keeping the collections of fossils as well as for studying and systematically cataloguing them.

EARLY DEFINITIONS

According to its original definition (1868–1869), the Shasta group[4] embraced strata ranging in age from the Gault to the

[2] Diller, J. S., Cretaceous and early Tertiary of northern California and Oregon: Geol. Soc. America Bull., vol. 4, pp. 211–216, 1893.

[3] Diller, J. S., and Stanton, T. W., The Shasta-Chico series: Geol. Soc America Bull., vol. 5, pp. 438–442, 1894.

[4] Whitney, J. D., Preface: California Geological Survey, Paleontology, vol. 2, p. xiv, 1869.

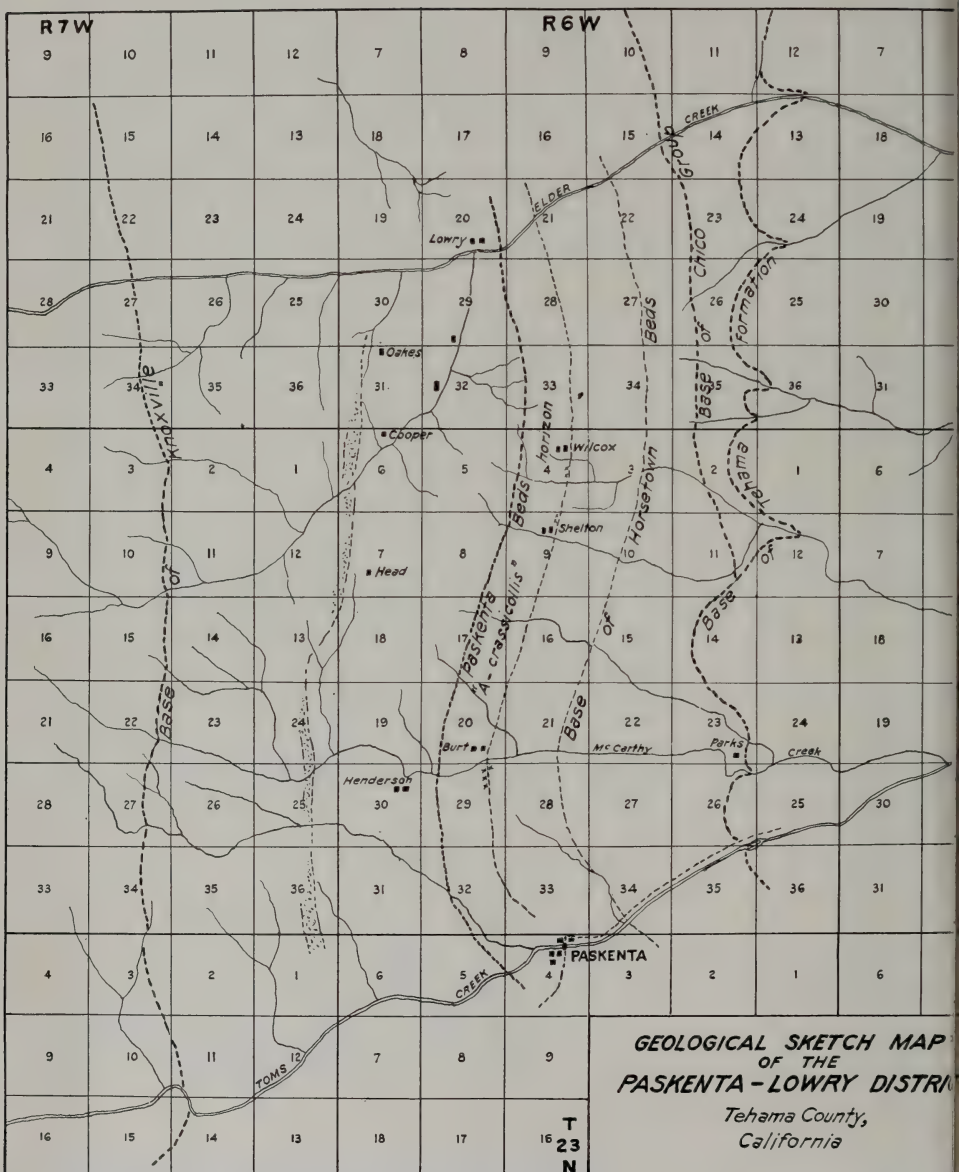

R7W
R6W
ELDER
CREEK
Lowry
Oakes
Cooper
Head
Wilcox
Shelton
Burt
Henderson
McCarthy
Creek
Parks
PASKENTA
TOMS
CREEK
Base of Knoxville
"Paskenta A-crassicollis" Beds
Horizon
Base of Horsetown Beds
Base of Chico Group
Base of Tehama Formation
T 23 N
GEOLOGICAL SKETCH MAP OF THE PASKENTA-LOWRY DISTRI
Tehama County, California

FIG. 2.

PLATE III

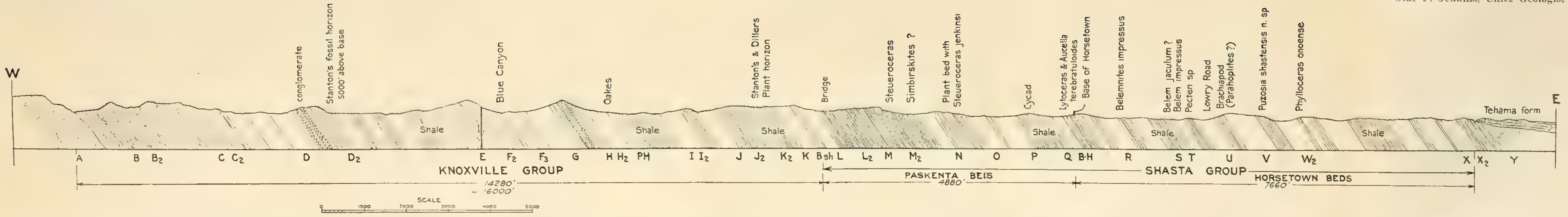


PLATE III. Geologic profile along McCarthy Creek (see Fig. 2), southwestern Tehama County, California, showing by a series of letters the stratigraphic position o fossil horizons, as explained in the accompanying report. Prepared by F. M. Anderson

Neocomian, as known in the European scale. We may now logically and with advantage adhere to this definition, and accordingly exclude, as should always have been done, any strata not coming within its defined scope.

In the early stages of this study this could not so readily be done, but with the further development of the science, and with the collection of better and more determinative fossils, this is not only possible, but it becomes even necessary, if we would keep pace with paleontologic progress.

In 1885 the Knoxville group was defined,[5] described and mapped as embracing, and as illustrated by, the Mesozoic deposits existing in the district about Knoxville, Napa County, and similar, or contemporary beds in other areas of the Coast Ranges of California. White [6] tentatively suggested that these beds formed part of the Shasta group, but this view was not supported by any valid evidence, paleontologic or other, and as it now appears, was contrary to evidence, and should accordingly be abandoned, not only as being inconvenient, but as untenable.

Quite as erroneous was the view that the serpentines of the Coast Ranges were metamorphic products of the Knoxville group, or that this group included any important class of metamorphic rocks with which it is associated, especially in the type district about Knoxville. The basement complex which constitutes the floor upon which the Knoxville beds were laid down includes various types of metamorphic rocks, sedimentary and igneous, but as to their ages little can be said here. Some of these sedimentary formations are known to be of Paleozoic age, and some may prove to be Triassic, or in part early Jurassic.

DISTINCTNESS OF KNOXVILLE AND SHASTA GROUPS

While no pronounced stratigraphic break in this Mesozoic sequence has been discovered in the district covered by this investigation, a line of demarkation is clearly indicated by fossil evidence, both above and below, as will be shown. This fossil evidence includes various forms of Mollusca, bivalves, gastropods, etc.; various classes of Cephalopoda, Ammonites, Ammonoids and Belemnites; and in addition, various plant horizons, the ages of which can be, and in fact have already been, determined. The evidence derived from all these sources is harmonious, and should leave little room for doubt as to the main points here proposed respecting the division of the sequence, or as to the classification of its different parts.

Paleontologists who have studied the faunas of the Knoxville group have long suspected that a large part of it, as formerly understood, might be distinct from the Shasta group,[7] and this belief was presumably held by Becker himself in proposing the name, perhaps basing his views upon stratigraphic evidence alone.

THE KNOXVILLE GROUP

In this district all the strata that can properly be classed as Knoxville come within the limits of the lower 16,000 feet, or less, of this

[5] Becker, G. F., Notes on the stratigraphy of California: U. S. Geol. Survey Bull. 19, pp. 8–9, 1885.

[6] White, C. A., The Shasta group: U. S. Geol. Survey Bull. 15, pp. 18–32, 1885.

[7] Hyatt, A., Trias and Jura in the Western States: Geol. Soc. America Bull., vol. 5, p. 404, 1894.

section, and clearly below the portion embraced in the Shasta group (Neocomain to Gault), as defined by Whitney. At its base the Knoxville group begins here with a clear unconformity, already well described by Diller, as it does in the type district itself. The underlying rocks include a variety of igneous, sedimentary and metamorphic types. Above the base there is a great succession of sandstones, conglomerates and shales, some of which are more or less sandy. Shales form the predominating element, in this particular district forming perhaps 75 per cent of the whole. In these shales are found many scattered calcareous layers, 6 inches to a foot or more in thickness, and usually lenticular, disappearing within a few hundred feet.

Throughout this succession are interspersed many fossil horizons, some of which are given below. Each new excursion into the field yields genera and species new or hitherto unknown in California, and with each the evidence becomes more convincing that the Knoxville is not only very distinct from the Shasta group, but belongs to a distinct system.

Some of the fossils, or fossil zones, found in the Knoxville of this section, and near it, are given below in the order of their occurrence, lettered from below upward. Attached numerals indicate the projection, upon the profile, of localities not far from it, the zones of which can be followed readily. However, in the immediate vicinity of the profile the strata near the base are much disturbed, and are partly overturned.

Zone B represents the base of the Knoxville.

Zone B_2 is represented by a locality a few miles to the north of McCarthy Creek, on the NW¼ of Sec. 35, T. 25 N., R. 7 W., within 1200 feet of the base of the group, from which were obtained, *Aucella gabbi* Pavlow, *Aucella hyatti* Pavlow, and *Aucella stantoni* Pavlow.

The upward range of these several species is not fully known; nor is it claimed that this is the lowest fossil horizon, or that the list is exhaustive of the horizon represented.

Zone C_2 is represented by a locality a little to the southeast, and a little higher than the preceding, but within 2000 feet of the base of the group. It has yielded here *Aucella hyatti* Pavlow, *Aucella sollasi* Pavlow, and others.

According to A. P. Pavlow all of the preceding forms occur especially in the middle Portlandian of Russia, or in the zone of *Virgatites virgatus,* as known in Europe.

Zone D is represented by a conglomerate, the pebbles of which are chiefly siliceous cherts, quartzites and other metamorphic rocks.

Zone D_2 is represented by a locality near Elder Creek, within 5000 feet of the base of the group, from which Stanton has reported as occurring in great abundance *Aucella piochii* Gabb.

Zone E is a zone of minor faulting; throw not great.

Zone F_2 is a zone extending along Blue Canyon and southward, on east border of Sec. 36, T. 25 N., R. 7 W., some 8200 feet above the base of the group. This zone has yielded besides various types of fossil wood, *Aucella hyatti* Pavlow, *Aucella stantoni* Pavlow, and *Aucella*

CORRELATION TABLE OF LATE MESOZOIC ZONES IN THE COAST RANGES OF CALIFORNIA

Group	Beds	Stage	EUROPE AND SOUTH AMERICA	CALIFORNIA	Zone
		ALBIAN		Tehama Tuff Beds (Tertiary)	
SHASTA GROUP	HORSETOWN BEDS	ALBIAN / APTIAN		Aucella terebratuloides Phylloceras theresae n. sp. (Phylloceras onoense Stn.) Puzosia shastensis n. sp. (Zone with Parahoplites sp.)	 X W_2 V U
SHASTA GROUP	HORSETOWN BEDS	BAR-REM.		(Zone with Crioceras Percostatum) (Zone with Crioc. remondi)	
SHASTA GROUP	HORSETOWN BEDS	HAUTERI-VIAN	Lyticoceras pseudoregale (Burckh) Hoplites noricus Z.	Pecten californicus Belemnites cf. jaculum Belemnites impressus Belemnites impressus (Conglomerates)	T S R B-H
SHASTA GROUP	PASKENTA BEDS	VALANGINIAN	Polypt. polyptychus Z. Lyticoceras regale (Bean)	(Polypt. cf. polyptychus) (Polypt. broadi n. sp.) Aucella terebratuloides Lytoceras cf. batesi Tr.	 Q
SHASTA GROUP	PASKENTA BEDS	VALANGINIAN	Steueroceras permulticostatum (Str.)	Cycad etc. Steueroceras jenkinsi n. sp. Steueroceras sp.	P N
SHASTA GROUP	PASKENTA BEDS	VALANGINIAN		(Simbirskites mutabilis Stn.) (Bochianites sp.)	M_2
SHASTA GROUP	PASKENTA BEDS	INFRAVAL-ANGINIAN	Crasp. stenomphalus Z. Crasp. spaskensis Z. Steueroc. koeneni Z. (Spiticeratan)	Aucella crassicollis var. Auc. crassa—solida, etc. Steueroceras sp. Aucella inflata Toula	 M L
KNOXVILLE GROUP	AQUILONIAN	UPPER	Berrias. riasenensis Z. Aucella fischeri Auc. tenuicollis Auc. terebratuloides Crasp. caschpuricus Z. Aucella andersoni Auc. fischeri	Aucella fischeri Auc. tenuicollis Auc. terebratuloides Aucella andersoni Pav. Auc. cf. fischeri	 K K_2
KNOXVILLE GROUP	AQUILONIAN	MIDDLE	Craspedites nodiger zone	(Plant beds—Diller & Stanton) Aucella lahuseni Belem. tehamaensis	J_2 I
KNOXVILLE GROUP	AQUILONIAN	LOWER	Crasp. subditus zone Aucella hyatti Auc. tenuicollis Auc. subinflata Auc. terebratuloides	(Aucella fischeri) (Belemnites tehamaensis) Aucella stantoni Conglomerates (Perisphinctes sp. Stn.)	H_2 G
KNOXVILLE GROUP	PORTLANDIAN	UPPER	Perisphinctes giganteus zone Aucella subinflata Auc. terebratuloides	(Hoplites storrsi Stn.) (Phylloc. knoxvillense) (Belem. tehamaensis) (Aucella hyatti—stantoni) (Auc. attenuata n. sp.	 F_2
KNOXVILLE GROUP	PORTLANDIAN	MIDDLE		(Aucella piochii (Stanton)) Conglomerate	D_2 D
KNOXVILLE GROUP	PORTLANDIAN	MIDDLE	Virgatites virgatus zone Perisph. quenstadti Z. Perisph. boidini Z.	Aucella sollasi—stantoni Auc. hyatti—gabbi Pav. Aucella hyatti—gabbi Pav.	C_2 B_2
KNOXVILLE GROUP	PORTLANDIAN	LOWER		(near Knoxville) (Auc. sollasi-hyatti) (Auc. piochii—lahuseni)	
				Basement rocks (? in part, Franciscan)	

97834—pages 316-317

attenuata n. sp., the latter a very narrow and elongated species which recalls by its form and sculpture *Aucella arcuata* (Hyatt).

Apparently from this horizon, at or near Blue Canyon, Stanton[8] has reported numerous species including *Hoplites storrsi* Stn., *Phylloceras knoxvillense* Stn., and a little higher in the section, *Perisphinctes* sp.

In describing *Hoplites storrsi* Stanton compares it only with upper Jurassic (Tithonian) forms in Europe and Mexico. The aucellas listed above from this zone seem to be referable to middle Portlandian, as shown by Pavlow. Stanton says, in part:

"In the overlying shales, about 1000 feet above the horizon of *Hoplites storrsi*, *Aucella piochii*, var. *ovata* and *Belemnites tehamaensis* are abundant."

The Aucella species referred to appears to be identical with *Aucella russiensis*, as figured by Pavlow, who places it in the middle Portlandian of the Russian column, as also in the uppermost Aquilonian of that country. We should expect to find it in the same horizons here. In Stanton's description of *B. tehamaensis* he says, in part:

"There is a related species (*B. inequilateralis* Eich.) in the National Museum from the Aucella-bearing beds of Herendeen Bay, Alaska, and similar forms occur in the upper Jurassic of Europe, such as *B. obeliscoides* Pavlow."

The Aucella-bearing beds of Herendeen Bay referred to by Stanton seem to include upper Jurassic (probably Portlandian) strata, as well as some of lower Cretaceous age, possibly equivalent to the Shasta, in part:

Zone H_2 is represented by a locality near Mr. Oakes' house, a little higher in the section than Blue Canyon, which, among other forms, includes, *Aucella fischeri* d'Orb., *Belemnites tehamaensis* Stn.

Zone I is a calcareous band found on the upper McCarthy Creek, which contains among other forms, *Aucella fischeri* d'Orb., *Aucella stantoni* Pavlow, and *Belemnites tehamaensis* Stn.

Zone I_2 is represented by a locality some miles south of the section, north of the mouth of Grindstone Creek. It has yielded the following:

Aucella fischeri d'Orb.,
Aucella tenuicollis Pav.,
Crioceras n. sp.,
Bel. tehamaensis Stn.,
Bel. cf. *porrectus* Phill.,
Aucella hyatti Pavlow,
Aucella subinflata Pavlow,
Phylloceras knoxvillense Stn.,
Bel. cf. *obeliscoides* Pavlow,
Belemnites n. sp.

The long, slender and scarcely tapering species of Belemnite here compared to that of Pavlow, resembles it so closely that a new name can hardly be given to it. *Belemnites porrectus* Phill., occurs in the upper Jurassic of Speeton, England. Others will be described later. All of the species of Aucella in this list are included by Pavlow in the middle Portlandian of Russia. The stratigraphic position of the bed from which these fossils come is about 9200 feet above the base of the Knoxville, and not less than 2500 feet from the top.

[8] Stanton, T. W., Contributions to the Cretaceous paleontology of the Pacific coast; the fauna of the Knoxville beds: U. S. Geol. Survey Bull. 133, pp. 15, 16, 18, 1895.

Zone J is represented by a calcareous band found on McCarthy Creek, containing *Aucella tenuicollis* Pav. and fragments of fossil wood, some of which is carbonized.

Zone J_2 Not far above the preceding horizon is this important plant-bearing zone. It appears to contain the horizon first described by Stanton as being 13,000 feet above the local base of the Knoxville. Apparently the same horizon was later described by Diller [9] as found on McCarthy Creek 2 miles east of the Paskenta-Lowry road. The points described in these references so nearly coincide that they both seem to refer to the same horizon.

The plants obtained by Diller were determined by F. H. Knowlton, who ambiguously referred them to a horizon capable of being interpreted as Jurassic, while he freely admits that

> "There are several of the forms not specifically named, as pointed out under the above lists, that appear to have their closest affinities with Jurassic species, * * *."

Zone K includes the highest bed of the Knoxville from which fossils were obtained in this section. It is found on McCarthy Creek just north of Mr. Henderson's house. Here in a concretionary layer were found *Aucella fischeri* d'Orb. and *Aucella* sp. A thin bed of coal is said to have been found at this point, and fragments of wood are plentiful.

A locality often referred to by Stanton,[10] 3 miles northwest of Paskenta, is by its position, as well as by its fauna, referable to the upper part of the Knoxville group, and it appears to lie either in *Zone J*, or *Zone K*, or between them. Some of the forms figured by him from this place are admitted to be of Jurassic aspect and none of them have yet been found in the overlying Cretaceous beds.*

TYPE DISTRICT OF THE KNOXVILLE

A visit to the type district of the Knoxville, during the past summer by Olaf P. Jenkins and the writer resulted in the discovery near the Reed mine, on the west side of Davis Creek, of wholly unmetamorphosed beds, including heavy conglomerates, sandstones and shales, the latter containing good examples of *Aucella sollasi* Pavlow. At Knoxville were found sandstones with *Aucella piochii* Gabb (?), and a mile to the north *Aucella piochii, Aucella hyatti* Pavlow, *Aucella stantoni* Pav., and *Auc.* cf. *lahuseni* Pavlow. All of these species, according to Pavlow, are found in the Portlandian or Aquilonian of Russia, and should be expected in such horizons in California.

To the east of Knoxville are found beds, henceforth referred to in this paper as belonging to the Shasta group, but they appear to be

[9] Diller, J. S., Strata containing the Jurassic flora of Oregon: Geol. Soc. America Bull., vol. 19, p. 385, 1908. (Knowlton, F. H., p. 386.)

[10] *Op. cit.*, p. 16, 30.

* In the text, section and correlation column of the present paper various special forms of fossils have been given new names, without figures or descriptions, such as *"Steueroceras jenkinsi," "Bochianites paskentaensis,"* etc. Although this method is always regrettable, it seems to be pardonable in this instance, since the necessary space is hardly available, and the subject matter is too technical for the present purpose. It is expected, however, that all of these species will have their proper descriptions and figures along with many others, in an early publication by the California Academy of Sciences, in whose custody the types are to remain as a part of its permanent collections. These new species include both Knoxville (Jurassic) and Shasta (Lower Cretaceous) forms, the proper treatment of which hardly belongs to the present contribution.—F. M. A.

readily distinguishable from the beds found at either Knoxville or the Reed mine, included in the type locality. The thickness of the Knoxville group in this district was not determined by either Becker or the writer, although as estimated, it can not be less than 7000 feet, and it may be much more. However, it probably does not equal that of the beds assigned to the group in the McCarthy Creek section, or in sections between Knoxville and McCarthy Creek. The pebbles found in the conglomerates near the Reed mine are chiefly of siliceous cherts, quartzites, siliceous porphyrites, etc., but include no basic rocks in any way related to serpentine or peridotite. Many of them are fractured, and contain secondary pyrite.

FAUNA OF THE KNOXVILLE GROUP

As now known, the fauna of the Knoxville group includes about 50 species of marine fossil invertebrates, Mollusca, Cephalopoda and Brachiopoda. The list includes a number of species of Aucella of which Pavlow enumerates no less than 10. These form the dominating element of the fauna, and according to Pavlow are sufficiently diagnostic for the age determination of the group. Other species of this genus, not mentioned by Pavlow, have been found in the same beds, but they are of the same general types.

Besides the various species of Aucella, other molluscan types have been recognized, some of which have been described or noted by Stanton. The more diagnostic and trustworthy element of the fauna includes various species of Cephalopoda. Among these have already been mentioned, *"Hoplites" storrsi* Stn., *"Hoplites" dilleri* Stn., *Phylloceras knoxvillense* Stanton, *Perisphinctes* sp. (Stanton), *Belemnites tehamaensis* Stn., *Belemnites* cf. *obeliscoides* Pavlow, *Belemnites* cf. *porrectus* Phill., *Belemnites* sp.

The fauna of the Knoxville has been regarded by Stanton [11] as being sufficient to ally it closely with that of the Aucella-bearing beds at Catorce, Mexico, in part at least, and the fauna as here restricted, seems to agree more nearly with the portion of the Catorce section which is properly below the Neocomian. A comparison of the Knoxville fauna with others to the north will no doubt disclose similar relationships, but this subject lies beyond the scope of the present paper.

It has been shown by Hyatt, J. P. Smith and others, and generally conceded by all, that most of the upper Jurassic faunas of the Pacific Coast are of boreal character; and the same views have been extended to a considerable portion of the Knoxville fauna as heretofore understood. In its restricted sense the Knoxville fauna is much more completely boreal in character than in the sense formerly employed, in which it was made to include strata later in age than Jurassic. The boreal character of the Knoxville is seen particularly in most of the species of Aucella found in it, as also in its cephalopods and other classes.

AGE OF THE KNOXVILLE GROUP

From the foregoing account it is clear that all of the fossils found in this section below the level of *Zone K* are, upon stratigraphic grounds, as well as specifically, to be regarded as belonging to, and

[11] *Op. cit.*, p. 27.

representing the Knoxville group, as was long ago determined by Stanton and Diller. It will be shown later that the strata containing this fauna lie below the lowest beds of the Cretaceous system (or the Shasta group), and that they can not, therefore, be included in this system, and, logically, must find place in some older horizons. Both Stanton and Pavlow, by whom most of the species coming from these beds were described, agree in laying stress upon the Jurassic aspect of most of them. In view, therefore, of their faunal aspect, as well as of their stratigraphic relations to the overlying beds, it must be concluded that none of the strata of the Knoxville group can be younger than the uppermost Jurassic (Aquilonian), while many of the species seem to have their closest affinities in the Portlandian. Reference should be made also to the enormous body of the Knoxville (14,280 feet) lying below the lowest beds of the Cretaceous.

It is interesting to note in this connection that much corroborative evidence as the Jurassic age of the Knoxville group is to be derived from a study of the stratigraphic relations of the ''Jurassic flora of Oregon,'' described by Ward and Fontaine [12] and later discussed by Diller and Knowlton.[13]

DISTRIBUTION OF THE KNOXVILLE

From Elder Creek the Knoxville beds have been followed northward to Beegum Creek, southwestern Shasta County. A traverse and search along Red Bank Creek by A. Gregersen and R. W. Burger, during the past summer, resulted in the discovery of a few fossils, and the recognition of some fossil horizons belonging to this group. The beds are here considerably more sandy and have a greater aggregate thickness than on McCarthy Creek, but throughout are well exposed. The lower portion of the section is much disturbed, the strata standing at a high angle, or nearly vertical. Approximately 9500 feet above the base a few fossils were found, including *Aucella* cf. *subinflata,* Pav., *Phylloceras knoxvillense,* Stanton, and a turbinate shell greatly resembling *''Trochus'' cupido* d'Orb., from the upper Jurassic of France. Still higher in the section, probably above the Knoxville was found an undescribed species of *Belemnites.*

North of Red Bank Creek the Knoxville becomes more sandy, and the exposed thickness becomes less, as if by overlap of later beds. Knoxville beds have not been proved to occur farther west than the Shasta-Trinity County line, although certain plant beds have been referred to as Jurassic. Only limited marine faunas have been found with them.

To the south of McCarthy Creek Knoxville beds have been followed continuously along the foothills to Wilbur Springs, southwest Colusa County, and from there westward toward Clear Lake. Between Clear Lake and Knoxville, Aucella-bearing beds outcrop at a number of places, as in Morgan Valley. The same beds with various fossils have been found about the Berryessa Valley, at Pope and Chiles valleys, and southward. They are known to occur also about the Santa Clara Valley (Stanton).

[12] Ward, L. F., and Fontaine, W. M., Status of the Mesozoic floras of the United States: U. S. Geol. Survey Mon. 48, pp. 47–145, 1905.

[13] *Op. cit.,* Diller, pp. 371, 379, 386.

On the north flank of Mount Diablo is the type locality of *Aucella piochii* Gabb, which occurs low in the section described in this report. Farther south in the Diablo Range these beds have been definitely recognized at a number of points, such as a little north of Pacheco Pass, west and south of the Vallecitos, west of Coalinga and in the Waltham Creek Valley. They have also been recognized near Santa Margarita and San Luis Obispo,[14] and in the mountains north of Santa Maria,[15] and they have been reported in the Santa Ynez Range. Still farther south Aucella-bearing beds of the same type have been reported by J. R. Pemberton in the district west of the Fernando Valley, Los Angeles County.

In most, if not in all places, where proved Knoxville strata occur in the Coast Ranges of California, they lie upon the landward (eastern) side of older mountain areas, from which they dip away to the eastward, as is the case in the Great Valley, as well as in other areas southward. In most places there are basal, or near basal, conglomerates, which indicate their derivation, in large part, from westerly land areas. They belong, therefore, to landlocked basins of deposition, with doubtless wide outlets to the open sea. In this respect the Knoxville beds are not unlike other Jurassic areas well known in California, including the Mariposa beds, of somewhat older age (lower Portlandian or Kimmeridgian).

THE SHASTA GROUP

Overlying the Knoxville strata, with seeming conformity in this district, there is a succession of beds of almost equal thickness (12,540 feet) bearing distinctly Cretaceous faunas, and few, if any of the species found in the Knoxville beds beneath. These faunas indicate horizons ranging from Infra-Valanginian to upper Aptian (lowermost Neocomian and younger). At the top these beds are covered by tuffs of the Tehama formation. The lower portion of the Shasta group, here called *Paskenta Beds*, includes some 4880 feet of strata, extending up to the lower limit of the Horsetown beds, as interpreted by Stanton, and also by others.

The lower part of the Paskenta beds (1500 feet) is characterized by species of Aucella, belonging to types very different from those in the beds beneath. Among these occur such forms as *Aucella inflata* Toula, *Aucella uncitoides* Pavlow (?), *Aucella keyserlingi* Lah., *Auc.* cf. *crassicollis* Keys. This part of the section is designated as *Zone L* on the profile.

About 1300 feet above the base of the Paskenta beds (Shasta group) appears a still more distinctive horizon, *Zone M* on the profile. In this horizon occurs *Aucella keyserlingi* Lah., *Aucella crassa* Pavlow, *Aucella solida* Pavlow, *Aucella* cf. *crassicollis* Keys., and *Aucella terebratuloides* Lahusen. At this horizon also were found, *Steueroceras* sp., *Lytoceras* sp. (group of *L. batesi* Trask) *Belemnites impressus* Gabb, etc. It was apparently from this horizon that Stanton[16] reports *Desmoceras californicum*, *Hoplites crassiplicatus* and other Cretaceous types.

[14] Fairbanks, H. W., Description of the San Luis quadrangle (Cal.): U. S. Geol. Survey Geol. Atlas, San Luis folio (No. 101), 14 pp., 1904.

[15] Crickmay, C. H., A new Jurassic ammonite from the Coast Ranges of California: Am. Midland Nat. vol. 13, pp. 1–11, 1932.

[16] *Op. cit.*, p. 17.

The lower portion of the Paskenta beds, *Zones L* and *M*, as shown in the profile, seem to represent the so-called "*Aucella crassicollis* zone" of Diller and others. In this part of the section the sediments suddenly become coarser, and the faunal change in the district is abrupt.

While the lower beds with *Aucella inflata* may represent the Infra-Valanginian, the higher beds, *Zone M*, contain a fauna that seems to fit more definitely into the lower Valanginian of Kilian, of Pavlow, and perhaps of Spath. Not far from this latter horizon, possibly below it, should be here included, *Zone* M_2 of the Wilcox and Shelton ranches, farther north. On these ranches, at the top of some 1200 feet or more of sandy shales, such as those found on McCarthy Creek, occur: *Aucella crassa* Pavlow, *Aucella solida* Pavlow, *Aucella* cf. *crassicollis* Keys., and with them, *Simbirskites mutabilis* Stn., *Simbirskites* n. sp., and *Bochianites* n. sp. This horizon is referred by Spath[17] to the top of the Infra-Valanginian (zone of *Craspedites stenomphalus*).

Zone N (McCarthy Creek). Some 2400 feet above the base of the Paskenta beds (Shasta group) was found a plant horizon, with numerous fragments of partly fossilized (and carbonized) wood and leaves. Along with these were also found *Steueroceras jenkinsi* n. sp., *Steueroceras* n. sp., resembling respectively, *St. permulticostatum* (Steuer), and *St. intercostatum* (Steuer), and with them in the same beds, *Astieria* cf. *astieri* d'Orb. This horizon appears to belong in the middle Valanginian of the Argentine Andes, as shown by Gerth.[18]

Above the "*Aucella crassicollis* zone" the beds become decidedly more shaly, with less sandstone, and calcareous bands are somewhat rare. Some 1500 feet above the zone with *Steueroceras jenkinsi* was found a well preserved Cycad leaf, at *Zone P* (of the profile, McCarthy Creek). A few hundred feet higher were found in *Zone Q Lytoceras* cf. *batesi* Trask, *Aucella terebratuloides* Lah. *Zone B-H* (base of Horsetown), as interpreted by Stanton, appears to be situated but little above *Zone Q* in the profile. It is this horizon that seems to have yielded species of *Parahoplites* of the group of *P. weissi* Neum. & Uhlig. The Horsetown beds in this section have an aggregate thickness of nearly 7660 feet, and at the top contain *Phylloceras theresae* n. sp. and *Aucella terebratuloides* Lahusen. Above this horizon, *Zone X*, the Horsetown beds are covered by the tuffs above referred to.

FAUNA OF THE PASKENTA BEDS

In the Paskenta beds of western Tehama County, between Toms Creek and the North Fork of Cottonwood Creek, some 47 species of marine fossils have been found, only a few of which have been mentioned above. The total list includes:

amonites,	11 species,	other cephalopods,	4 species,
aucellas,	7 species,	other bivalves,	17 species,
brachiopods,	2 species,	gastropods,	6 species.

In the lower 1300 feet of the section Aucellas are extremely abundant and form the dominating element of the fauna. The greater number of these belong to the larger types, such as *Auc. crassicollis*,

[17] Spath, L. F., Geol. Magazine, vol. 61, p. opp. 80, 1924.
[18] Gerth, H., Actas Acad. Nac. de Cienc., vol. 9, 1925, Cordoba.

Auc. inflata, Auc. crassa, Auc. solida, etc., and rarely smaller forms, and few if any that characterize the Knoxville beds. These larger types appear suddenly and rapidly increase in number and variety, through more than 1000 feet of strata. Above the lower 1200 feet appear most of the cephalopods included in the foregoing lists, such as *Lytoceras* cf. *batesi*, *Steueroceras* (2 or 3 sp.), *Desmoceras californicum*, *"Hoplites" crassiplicatus*, *Belemnites impressus*, etc.

In contrast with the boreal aspect of the Knoxville faunas, the southern, subtropical character of the Paskenta is strikingly noticeable, as seen in the Argentine types. The sudden change in the types of Aucella, the rapid development of the newer types, the disappearance of the older types, as well as the sudden change in the character of the sediments, seem quite significant. Later, their almost sudden disappearance at the epoch of Cephalopod invasion, seems no less significant. Whether the fact that the Aucellas almost disappeared at this time was due to the appearance of aggressive, carniverous cephalopods, or whether it was due to changes of ocean currents and temperature, or to both these causes combined, is somewhat conjectural at present.

It is certain, however, that the faunal changes were great, and that they were probably induced by widespread earth movements (diastrophism) which brought to these areas of the coast faunas of a southern character, and that these newer forms at once displaced those of the earlier epochs and of boreal types, that occupied the Knoxville seas.

The upper part of the Paskenta beds, above the *Aucella crassicollis zone* soon loses most of the Cephalopod species that occur near its top, as if they too soon died out with the disappearance of Aucellas.

DISTRIBUTION OF THE PASKENTA BEDS

Paskenta beds seem to be less widely distributed than those of the Knoxville, partly because since their volume is smaller, they have less chance to appear in outcrop. From the type district, they have been followed northward to the Cold Fork, Middle Fork and North Fork of the Cottonwood Creek, and from there westward far into Trinity County, and as far beyond the limits of the Knoxville; and thus they show a wide overlap across the latter upon the older rocks of the basement series. Paskenta beds have been identified at Reading Creek, Rattlesnake Creek and at Big Bar on the Trinity River. South of Paskenta they form the prominent hills east of the Stony Creek, Little Indian and Bear Creek valleys; to the east of Knoxville, and probably, in part, east of Berryessa Valley. They have been proved here only as far south as Knoxville. They have been shown to outcrop at Mount Diablo, and in the Diablo Range, and also they have been identified in the Santa Lucia Range as far south as Pine Mountain, where they were observed by the writer and H. W. Fairbanks in 1894, but were included by the latter in the Knoxville group.[19]

The geographic distribution of the Paskenta beds does not conform to that of the Knoxville, either to the north or to the south, but in both directions there are evidences of their disconformity with the latter.

---

[19] Fairbanks, H. W., The stratigraphy of the California coast ranges: Jour. Geology, vol. 3, pp. 420–421, 1895.

THE HORSETOWN BEDS

The later portion of the Shasta group is made up of strata assigned to the Horsetown beds by Stanton. As shown in the profile the Horsetown beds have here a total thickness of 7660 feet, of which the larger part consists of dark colored clay shales, becoming a little sandy at the top. No sharply defined line separates these from the Paskenta beds beneath, and the point of division is set somewhat arbitrarily at a horizon of cephalopod forms that seem to have exceptional significance, as well as considerable geographic extent. This horizon is better known in the district of the North Fork of Cottonwood Creek, but it has also been found as far south as Wilbur Springs. This horizon, which will be described later, is indicated in the profile as *Zone B-H*. One element of its fauna that seems distinctive consists of a group (three or more species) of *Parahoplites*, of the general form of *Parahoplites weissi* Neum. & Uhlig. Above this horizon are other zones characterized by various species of Ammonites, Ammonoids, Belemnites and other forms showing Barremian and Aptian ages.

A notable feature of the Horsetown beds is the almost total disappearance of the genus *Aucella,* although related forms are well known. The highest point in the section at which Aucella has been found is near the top of the Horsetown beds, not far from the margin of the Tertiary tuff beds of the Tehama formation. In part, the fauna of the Horsetown may be regarded as having been derived from that of the Paskenta beds, but in part also, as better shown in the Cottonwood section, it contains various types of a north European aspect. But this subject must remain for future consideration.

RELATIONS OF SHASTA AND KNOXVILLE GROUPS

The stratigraphic relations of the two major groups herein discussed is best illustrated in their regional distribution. Although in some districts, as in that of this profile, there is apparent conformity between these two groups, such conditions may well be exceptional and misleading. In the northern districts—western Shasta County, and more especially in Trinity County—the Paskenta beds overlap the Knoxville group, and rest directly upon its basement rocks (Paleozoic, or early Mesozoic), as may be seen from the accounts given by Diller.[20] To the south, as in the Diablo Range, no beds that have been identified as Paskenta appear, and there are few exposures, if any, of the Shasta group, while later Cretaceous (Chico) strata are found resting unconformably upon Knoxville beds. If Paskenta deposits were ever formed in these areas they have now disappeared, or have been overlapped by later Cretaceous beds. In any case it appears that the diastrophic record is distinctly different here from that in the north, and an epoch of uplift and of differential movement must be supposed for the beginning of the Shasta epoch, that is, between the close of the Knoxville and the opening of the Chico epochs, as has been stated elsewhere. It may later be shown that in some of the older Coast Ranges to the south, Paskenta beds are transgressive upon pre-Knoxville formations, but this has not yet been shown. At all events, the fact that the two groups are not coextensive in their distribution would seem to be significant of widespread earth movements at the close of the Knoxville, that is, of

[20] *Op. cit.*

Jurassic time. These movements will doubtless be recognized as a part of the world wide orogenic and other movements at the close of the Jurassic period.

RELATION OF KNOXVILLE TO OTHER JURASSIC OCCURRENCES

It was believed by both White and Hyatt, and the view has been accepted as possible by others, that the older Knoxville beds were either contemporaneous with the Mariposa beds, in part, or that the time interval between them was extremely short. This view was discarded by Diller and Stanton, who maintained that a considerable time interval elapsed between the epochs of their deposition. Considering the more significant facts pertaining to this question, their lack of contiguity, the absence of any common species, as far as known, the extensive metamorphism claimed for the Mariposa slates and the general absence of such in the Knoxville, it seems that there could be little to support the view that they were, even in part, contemporaneous.

It appears possible that at the close of the Mariposa epoch a general disturbance of the Pacific border region, as of other parts of the earth, took place, which elevated the continental (eastern) side of the then existing basin, while at the same time the pre-Knoxville Coast Ranges north of San Francisco Bay suffered subsidence. Such differential movements would result in a shifting of the locus of marine occupation and deposition, with a retreat of the sea from the continental side, and its transgression upon the terrains of the opposite (western) side.

Toward the south, as in the Diablo Range, the movements may have followed in kind those of the upraised Sierran block. But until the areas of the Knoxville strata are more fully known and mapped, only tentative and somewhat speculative suggestions can be made.

IGNEOUS INTRUSIONS

Large areas of pre-Knoxville rocks in the Coast Ranges both north and south of San Francisco Bay, are well known. These areas contain rocks of various ages, including crystalline schists, some sediments of Paleozoic age, and perhaps also some that are early Mesozoic, which possibly include the so-called "Franciscan series." Some of these terrains have formed parts of the floor upon which the Knoxville sediments were deposited, as already shown. Involved with them are many areas of igneous rocks, including serpentine (or peridotite), and in some localities their contacts show intensive metamorphism.

The Knoxville beds for the most part are found in areas peripheral to these older terrains in which serpentine forms a conspicuous feature, although in some places they appear within, or upon them. The time of intrusion of these basic rocks is not fully known. It has frequently been claimed that these intrusions are post-Knoxville in age, and that the Knoxville beds have been penetrated and metamorphosed by them, and further that occurrences proving this are frequent in the Coast Ranges. This has been maintained by Fairbanks, Diller, Anderson, Kramm[21] and other writers in the past. Without endorsing this view, it may be admitted that in some observed cases it is difficult to deny that

[21] Kramm, H. E., Serpentines of the central Coast Ranges of California: Proc. Am. Phil. Soc., vol. 49, 315–349, 1910.

such are the appearances. Nevertheless, in view of the broader well-known facts, the logical presumption is, in general, to the contrary, as could easily be shown. In most cases, moreover, where proved Knoxville beds are found in contact with peridotites (or serpentine) there is a total absence of metamorphic products, and this fact can not be overlooked. However, serpentines, themselves, have been penetrated by later igneous rocks (porphyrites and quartz-porphyries) and such intrusions may well have extended into bordering formations, even the Knoxville.

SUMMARY OF RESULTS

The chief results of this stratigraphic study has been the definite segregation of the strata hitherto commonly confused and referred to as "Knoxville," and as forming a part of the Cretaceous system in California. In this great succession of strata, of which the total thickness approaches 27,000 feet, two distinct systems have been recognized, which for the most part, wherever they have been found in this State occupy distinct and separate areas. The older system, which is well represented in the type district about Knoxville and the Reed mine, is clearly seen to be of Jurassic age, and although it resembles the later group in its lithology, on the whole it occupies distinct areas of its own.

The later, Shasta group, which in the northern Coast Ranges (south of Shasta County) borders the Knoxville on the east, likewise occupies its own areas, and is clearly of Cretaceous age (Neocomian to Gault, inclusive), as stated in its original definition. It is seen to overlap the Knoxville group to the north, resting upon older basement rocks, far beyond geographic boundaries of the same, while to the south (Diablo Range, etc.) it is not found associated with the Knoxville, or only rarely so.

As, in the main, the areas of the two groups are distinct, where they contain fossils the mapping of them as separate units offers no great difficulty. Even where they occupy contiguous areas the line of demarkation is usually simple and can readily be followed or in any case can be approximated. No geological map of the State should be regarded as complete, which does not segregate the larger areas of these two groups (or systems) of strata, although this may not be practicable for smaller areas, or without fossil criteria.

ECONOMIC DEPOSITS

The economic features of the deposits included in either of these groups of sedimentary rocks are not very great so far as they are known at present, although in view of the lithologic character of either, various possibilities suggest themselves. Where the lime content in either of them is sufficiently high, as in some cases it has been proved to be, it is possible that natural cement rock may be found in quantity to be attractive.

The economic value of the Knoxville beds may be greater, but as yet is quite unknown. It is possible, although not proved, that some of the older conglomerates may be auriferous to a workable degree. Some mineralization subsequent to deposition has already been mentioned.

Photograph by O. P. Jenkins.

FIG. 3. Looking northwest towards Toms Creek Canyon from Paskenta Road, two miles south of Newville. Terraces bevel upturned edges of Knoxville shale, in contrast to Knoxville conglomerate ridges in distance. Mountains on horizon are of pre-Knoxville metamorphic rocks. A short distance back of camera is base of Shasta series.

Photograph by O. P. Jenkins.

FIG. 4. Basal conglomerate (Paskenta beds) of Shasta group showing various blocks of transported Knoxville material lodged in Shasta conglomerate: Largest fragment, silicified wood; smaller white boulders, limestone containing Knoxville aucellas. To left, pick points to *Belemnites impressus,* a typical Shasta fossil. Location, 2½ miles south of Newville.

Photograph by O. P. Jenkins.

FIG. 5. Typical exposure of Knoxville shales with easterly dip. Looking southwest. Location, Blue Canyon, west of Oakes, NE¼ Sec. 36, T. 25 N., R. 7 W.

In some districts, such as the Berryessa Valley, petroleum has been found in Knoxville beds in limited quantity, and under more favorable conditions of structure larger quantities may later be found.

At the base of the Knoxville, and in the zone of contact with older (or younger) eruptive rocks many of the quicksilver deposits of California occur. This fact is taken as evidence that an epoch of extensive mineralization followed the close of the Knoxville, but it does not prove that an epoch of general intrusion of eruptive rocks followed it. The epoch of mineralization and of some alteration may well have coincided with that of the diastrophism intervening between Knoxville and Paskenta deposition, but that this was the epoch of major intrusion does not appear to be likely. The mineralization was of a milder nature.

The fact may here be recalled that petroleum has been noted in the quicksilver ores of many of the California mines. This fact was observed by Becker and others many years ago. It may be taken as an indication of the gentle character of the mineralizing activities of the time.

GEOLOGY OF A PART OF THE PANAMINT RANGE, CALIFORNIA[1]

By F. M. Murphy

OUTLINE OF REPORT

ABSTRACT

The Panamint Range is a tilted fault-block, uplifted probably in Tertiary time and rejuvenated by very complex recent faulting on the west. This great block is approximately 100 miles long, but the reconnaissance geologic map covers only a tract in the southern portion of the range about 21 miles from north to south. The oldest formation consists of a great thickness of undifferentiated and

[1] Condensation of a part of a thesis submitted to the Balch Graduate School of the Geological Sciences of the California Institute of Technology. Abstract presented before the Cordilleran Section, Geological Society of America, April 13, 1929. (Geol. Soc. Am. Bull., vol. 41, p. 152, 1930.)

regionally metamorphosed rocks, embracing schists, gneisses, and marble, predominantly of sedimentary origin, injected by granitic rocks and cut by diabase dikes. These are overlain by less highly metamorphosed slaty schists and dolomitic limestones, separated by a nonconformity from a succession of rocks consisting largely of limestones, dolomites, and schists. The age of the rock formations is unknown, but is believed to range from pre-Cambrian to Lower Paleozoic. Structure within the range is not entirely clear and that of certain rock masses is indeterminable. The older rocks on the west slope show a westward dip of the foliation, while the younger formations, forming the crest of the range and the Death Valley side, dip gently eastward.

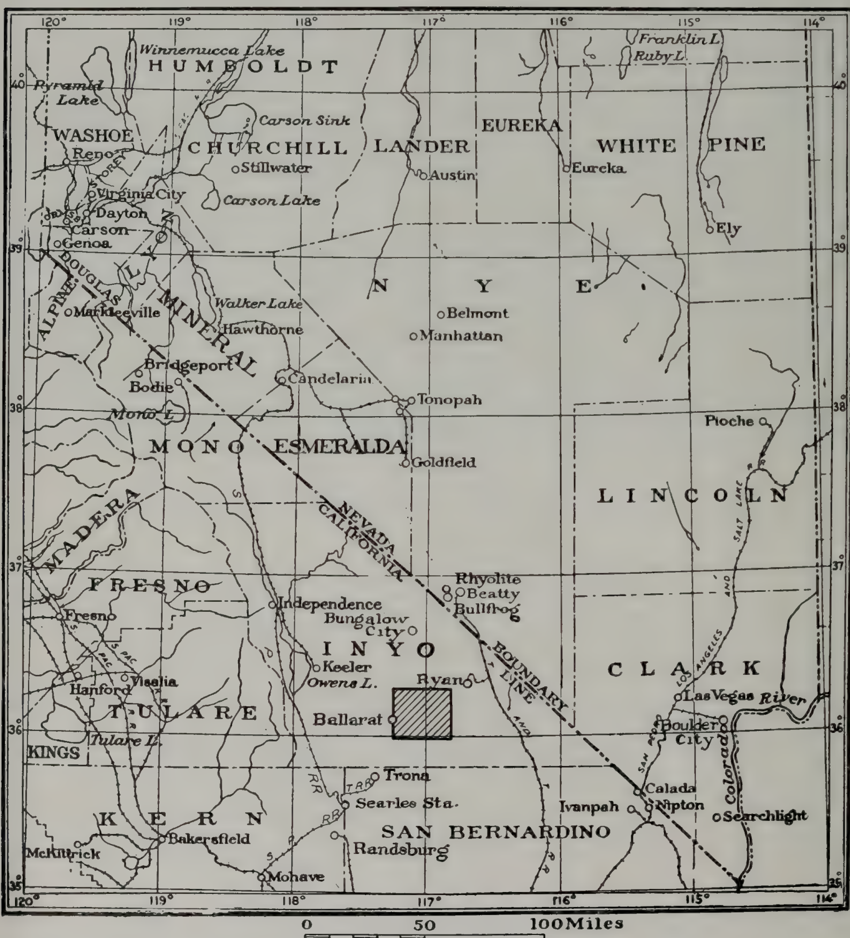


FIG. 1. Index map showing location of area (shaded) covered in this report.

INTRODUCTION

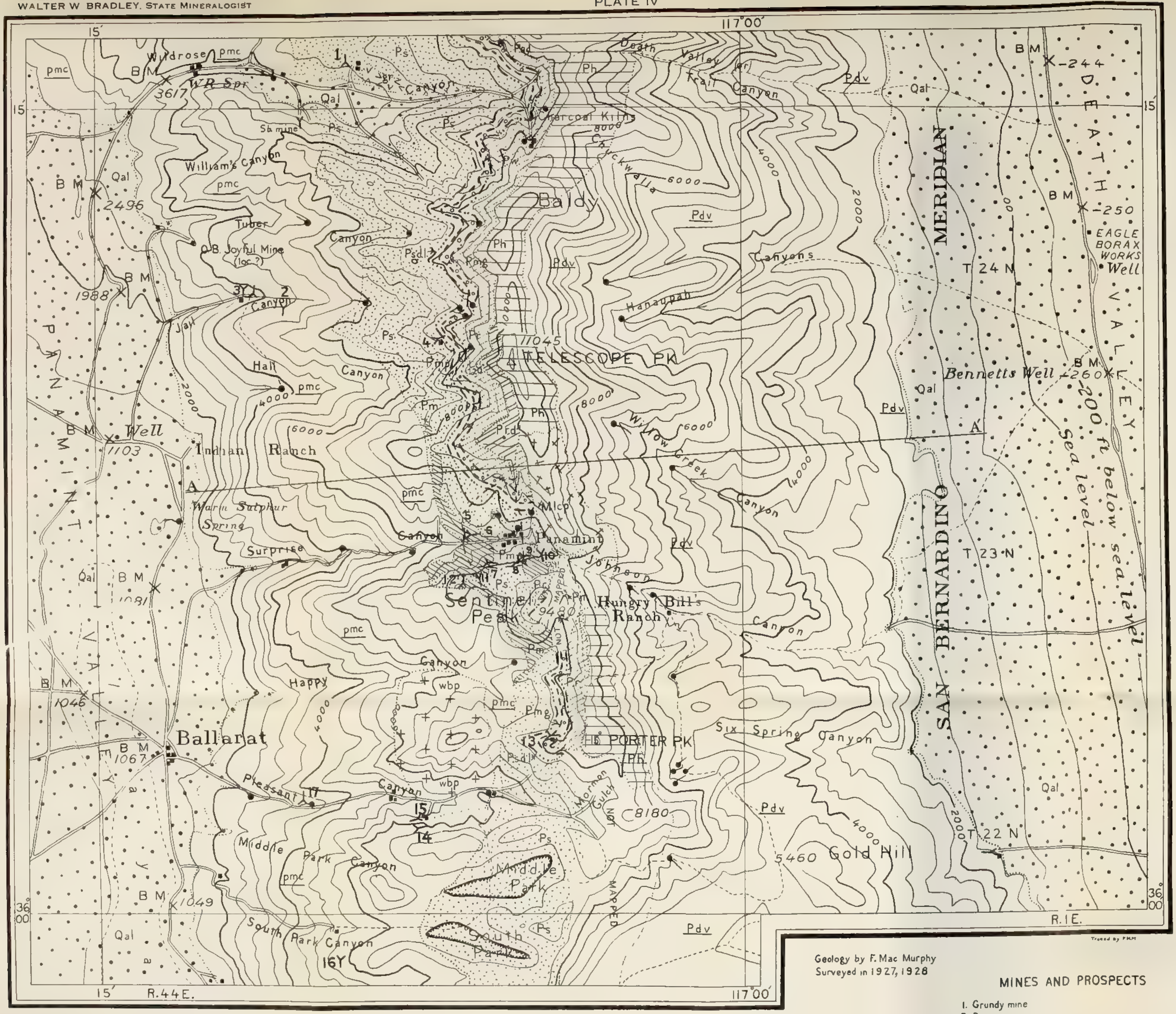
Object of the Report.

A twofold project of research in the Panamint Range was undertaken by the writer in 1926 upon the suggestion of Mr. L. F. Noble. In subsequent field seasons, a detailed study of the Panamint silver district and a general investigation of the geology of the region, were carried out. The report on the economic geology of the mining district

CALIFORNIA STATE DIVISION OF MINES
WALTER W. BRADLEY, State Mineralogist

PLATE IV

GEOLOGIC BRANCH
OLAF P. JENKINS, Chief Geologist



Geology by F. Mac Murphy
Surveyed in 1927, 1928

Base enlarged from U.S. Geol. Survey Maps of the Ballarat, Furnace Creek and Searles Lake quadrangles
Culture revised and minor topographic changes made in 1928 by F. Mac Murphy

Scale
2 1 0 2 4 Miles
2 1 0 2 4 Kilometers
Contour interval 500 feet.
Datum is mean sea level

TRUE NORTH — MAGNETIC NORTH — 16°
APPROXIMATE MEAN DECLINATION 1911.

RECONNAISSANCE GEOLOGIC MAP OF A PART OF THE PANAMINT RANGE, CALIFORNIA

LEGEND

SEDIMENTARY AND METAMORPHIC ROCKS

QUATERNARY
- Qal — Alluvium
- Pdv — Death Valley formation

LOWER PALEOZOIC (?) — Telescope group
- Ph — Hanaupah formation
- Prd — Redlands dolomitic limestone
- Pr — Radcliff formation
- Psd — Sentinel dolomite
- Pw — Wildrose formation
- Pmg — Mountain Girl conglomerate-quartzite

DISCONFORMITY(?)
- Pmp — Middle Park formation
- Psdl — Sour Dough limestone

NONCONFORMITY
- Ps — Surprise formation
- Pm — Marvel dolomitic limestone

PROBABLE UNCONFORMITY

PRE-CAMBRIAN AND LOWER PALEOZOIC (?)
- pmc — Panamint metamorphic complex

IGNEOUS ROCKS

PRE-CAMBRIAN(?)
- wbp — World Beater porphyry (porphyritic granite)

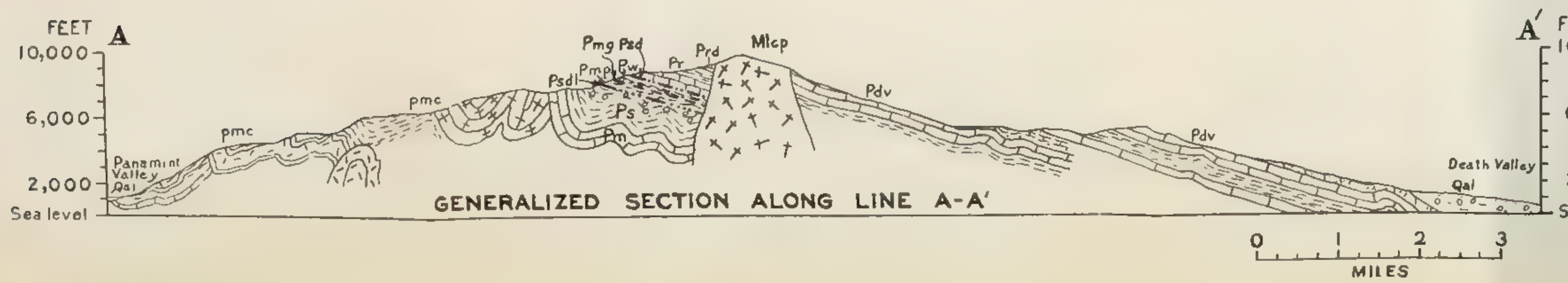
MESOZOIC (?)
- Mlcp — Little Chief porphyry (granite porphyry)
- gr — granite

Approximate location of the Panamint District as mapped

Actual and inferred boundaries
Trail
Tunnel
Springs

MINES AND PROSPECTS

1. Grundy mine
2. Burro mine.
3. New Discovery (Gem group).
4. Horn Spoon mine
5. Camp Bird mine
6. Stewart's Wonder workings.
7. Wyoming workings.
8. Kenneth prospect.
9. Revenue prospect.
10. Bachelor workings.
11. Hemlock mine.
12. Alabama and Hudson River prospects.
13. Mt. Girl and Mt. Girl Ext. properties.
14. Radcliff mine
15. World Beater mine
16. Big Horn mine (formerly Gibraltar).
17. Anthony mine



GENERALIZED SECTION ALONG LINE A-A'

Note: Elevation of U.S. Coast and Geodetic Survey's triangulation station on Sentinel Peak established in 1926 is 9627 feet above mean sea level.

3

re
na
T
st
of
bu
th
T
yo
ge

o

t.
I
d
c

has already been completed. In the regional study, petrology and stratigraphy were the most carefully investigated fields of geology, while the intricacies of faulting marginal to the range, were studied only in a general way. This faulting, however, is expected to be the subject of further investigations in the general region. The Panamint Range is one of the most prominent topographic features of the arid region of southeastern California and is one of the characteristic, though little known, Basin Ranges of this district. In this connection, its form, composition, and structure has especial significance. It is the hope of the writer that this contribution may be useful in extending geologic knowledge of this interesting desert range.

Location.

The area covered by the accompanying reconnaissance geologic map, embracing the tract of country that forms the particular subject of this investigation, is situated in Inyo County, southeastern California. Its general geographic position and routes of access are shown on the index map (Figure 1). The area is approximately 21 miles from north to south and 24 miles from east to west, and lies between parallels 36° 00′ and 36° 16′ and meridians 116° 53′ and 117° 15′. It contains about 500 square miles and includes a portion of the southern part of the Panamint Range.

The mountains are rather inaccessible especially the eastern side, bordering Death Valley. Apart from a few canyon roads on the west side of the range, the higher parts are reached only by a few rough trails. The almost deserted town of Ballarat, the only settlement in the area, is located at the foot of the range, in Panamint Valley.

The silver-bearing quartz veins of the Panamint district are of chief economic interest, although deposits of gold, lead, and antimony also occur in various places in this part of the range. The silver ores occur for the most part in limestone, but are also found in schist, in well-defined fissure veins, of probable Mesozoic age.

Previous Work.

The publications listed below[2] deal with the geology of this part of California. Only a few of them, however, specifically relate to that part of the Panamint Range discussed in this report. A paper on the geology of the Panamint mining district has recently been published elsewhere.[3]

---

[2] Fairbanks, H. W., Preliminary Report on the Mineral Deposits of Inyo, Mono, and Alpine Counties. Calif. State Mining Bureau, 12th Ann. Rept., pp. 472–478, 1894; * * * Notes on the Geology of Eastern California. Amer. Geol., vol. 17, pp. 63–74, 1896; * * * Mineral Deposits of Eastern California. Amer. Geol., vol. 17, pp. 144–158, 1896.

Spurr, J. E., Descriptive Geology of Nevada South of the Fortieth Parallel and Adjacent Portions of California. U. S. Geol. Survey Bull. 208, pp. 200–205, 1905.

Ball, S. H., A Geologic Reconnaissance of Southwestern Nevada and Eastern California. U. S. Geol. Survey Bull. 308, pp. 201–212, 1907.

Gale, H. S., Salines in the Owens, Searles, and Panamint Basins, Southeastern California. U. S. Geol. Survey Bull. 580, pp. 312–323, 1914.

Noble, L. F., The San Andreas Rift and Some Other Active Faults in the Desert Region of Southeastern California. Carnegie Inst. Wash. Yearbook, no. 25, pp. 425–428, 1925–1926.

Davis, W. M., The Rifts of Southern California. Amer. Jour. Sci., 5th Ser., vol. 13, pp. 57–72, 1927.

Wolff, John E., Route of the Manly Party of 1849–50 in Leaving Death Valley for the Coast. Pasadena, The Author, 1931.

[3] Murphy, F. Mac, Geology of the Panamint Silver District, California. Econ. Geol., vol. 25, pp. 305–325, 1930.

FIG. 2. General view of the eastern front of Panamint Range across Death Valley, from Dante's View in the Black Mountains. The difference in elevation is from approximately 250 feet below sea level to 11,045 feet above.

The Panamint Range was probably named by John Lilliard of the Darwin French party—a group of prospectors from San Francisco, who in May, 1860, set out in search of a mythical silver deposit, the 'Gunsight lead,' which was believed to have been discovered by the emigrant party that was lost in Death Valley in 1850.

Acknowledgments.

The writer desires to thank his many friends in the area for numerous courtesies extended, and to express his appreciation for their active interest shown during the progress of the work. He is especially grateful to Messrs. F. L. Ransome, J. P. Buwalda, Rene Engel, and J. E. Wolff for their kindness in accompanying him on short field trips to the region, for suggestions concerning many of the problems involved in the work, and for reviewing the manuscript.

Climate and Vegetation.

In consequence of the considerable difference in altitude there is a corresponding variation in both climate and flora between Panamint Valley and Death Valley on the one hand, and the Panamint Range on the other. The distinction ranges from those exemplified by the comparatively well-watered crest of the range, with its substantial timber growths, to the arid valleys with their scant growth of typical desert plants.

In the valleys the air is relatively dry throughout the year, the winters are moderately cold with occasional light flurries of snow, and the period from June until October is usually oppressively hot, both day and night. The mean summer temperature for Death Valley is about 96° Fahrenheit. In 1913 the United States Weather Bureau station at Furnace Creek (Greenland) Ranch, altitude 178 feet below sea level, recorded a shade temperature of 134° Fahrenheit. This is the highest officially reported natural shade temperature in the world. The mean winter temperature, as registered over a period of many years at the Furnace Creek Ranch, is about 60° Fahrenheit. Over a long period, the annual average precipitation for Death Valley is about 1.5 inches, but it is approximately twice that amount in Panamint Valley.

In the upper reaches of the Panamint Range, the winters are moderately cold; summer days are warm and the nights delightfully cool. It would be extremely difficult to estimate the precipitation in any considerable part of the Panamint Range, but it is of course very largely in excess of the precipitation in the adjacent valleys. The snow line rarely falls below an elevation of 6000 feet, although there are occasional exceptions. Cloudbursts and local excessively heavy rains occur both during the summer and winter.

The vegetation of the Panamint Range is typical of that of the higher desert ranges generally. Three distinct zones of plant growth can be made out. The lowest occupies the valleys on either side of the range and the desiccated slopes up to an altitude of about 6500 feet. The sparse vegetation of this zone includes Creosote Bush (*Larrea tridentata var. glutinosa*). The second zone is the lower half of the conifer belt and extends to an altitude of about 8500 feet. It is marked by the Desert Juniper (*Juniperus californica var. utahensis*)

and the Pinon Pine (*Pinus cembroides var. monophylla*) while common shrubs occurring in this region are: Mexican Tea (*Ephedra viridis*), Cliff Rose (*Cowania mexicana var. stansburiana*), and Common Sagebrush (*Artemisia tridentata*). The third zone is the upper conifer belt and extends from 8500 feet to the highest peaks and ridges of the range. The important representatives include the Limber Pine (*Pinus flexilis*) and the Hickory Pine (*Pinus aristata*) with an occasional Sierra Juniper (*Juniperus occidentalis*). Other shrubs are: Desert sweet (*Chamaebariaria millifolium*), Small-leaf Mahogany (*Cercocarpus intricatus*) while Mountain Mahogany (*Cercocarpus ledifolius*) is conspicuous as a shrub or tree.

BROAD TOPOGRAPHIC AND PHYSIOGRAPHIC FEATURES

The Panamint Range occupies a commanding position, forming the west wall of Death Valley and the east wall of the somewhat smaller, but very similar, Panamint Valley. It is about 100 miles long and extends from latitude 35° 35′ N. to 37° 00′ N. The line of demarcation between the Last Chance Range on the north and the Panamint Range on the south is not sharply defined. On the south the range terminates at Leach trough. It has a dominant north-northwesterly trend but the part of the range with which this paper is concerned, substantially parallels the meridian and averages about 18 miles in width. The rather sharp crested ridge, which marks the axis of the range and averages approximately 9500 feet above sea level, gradually culminates with commanding eminence in Telescope Peak, altitude 11,045 feet. From the sea level contour line in Death Valley to the summit of Telescope Peak, the average grade is 1000 feet to a mile for a horizontal distance of 11 miles. This steep acclivity is perhaps only exceeded in the United States by that of San Jacinto Peak in southern California. Though the east slope of the Panamint Range is therefore abrupt and rugged, it is less precipitous than that of the west flank.

The range is scored by a considerable number of great canyons, spaced at fairly equal intervals and extending generally normal to the trend of the range. These are separated by long rather even-crested ridges. The canyons are notably steep and rugged, with walls in some places rising vertically for hundreds of feet. This is especially true of canyons on the west side of the range. Locally they are mere slits in bedrock, and a few of them contain falls. The grade of the canyons on both flanks of the range average generally from 15 to 18 per cent.

On the east side of the range the contact of bedrock and alluvium is sinuous while on the west side it is relatively rectilinear. The heads of the alluvial fans on the west side of Death Valley attain a height of about 2000 feet above the playa, which nestles below the steep west escarpment of the Black Mountains. These huge fans coalesce to form a belt averaging four miles in width along the east base of the Panamint Range. The piedmont belt is broadest in Death Valley opposite Dante's View (Figure 2) but diminishes in breadth farther to the north. On the east side of Death Valley playa, the alluvial fans flanking the Black Mountains are very small in comparison with those described above. They are, moreover, formed of fresh materials in

contrast to the decomposed rock debris of the fans on the west side. In Panamint Valley, which resembles Death Valley, the playa hugs the small alluvial fans to the east, along the base of the Panamint Range, while to the west of the playa long alluvial slopes rise to the flanks of the Argus Range.

Although mudflows have occasionally contributed to the formation of alluvial fans, the field evidence observed in this arid region has led the writer to consider that they are of minor significance as agents of erosion. A mudflow of considerable magnitude occurred in Surprise Canyon late in the afternoon of July 26, 1917, occasioned by a cloudburst near the head of Woodpecker Canyon, a north branch of Surprise Canyon. According to the only living witness of the flood, the water was 40 feet deep in the 'Narrows' of the canyon and the road was lowered 12 feet below its original level for a distance of about one mile. Like many of the mudflows described by Blackwelder,[4] the Surprise Canyon flow is characterized by preponderance of boulders. Its recency is indicated by absence of streamlet channels on its surface. It could not be ascertained how far the large fresh boulders, incorporated within the mudflow, were carried at the time of this flood, but in view of their well-rounded condition, it seems permissible to assume that most of them were not transported directly from their sources at the time of the flood. Trees up to $2\frac{1}{2}$ feet in diameter, however, were moved many miles down the canyon and were partly or completely buried in the layer of mud and rocks which covered the former surface of the fan. The present lobate layer of bouldery mud is 2 feet thick at its margin and covers roughly 10 per cent of the present fan area. Cutting by streams in the canyon below the mudflow surface varies widely from place to place, reaching a probable maximum depth of 15 feet. How much of this figure may represent dissection immediately after the flow of mud and rocks, can not of course be estimated but it may have been considerable.

Remnants of an old erosion surface are preserved in this part of the Panamint Range, like those previously noted by Ball [5] in the area farther to the north. Ball further mentions the existence of similar old topographic forms on the Kawich, Amargosa, and Belted ranges. Ferguson [6] found a similar topography on the Toquima Range. Meinzer [7] reported similar topographic forms on the Toyabe Range and Buwalda [8] described the occurrence of an early old-age topography on Cedar Mountain. Although vestiges of subdued topography are everywhere present on the western slope of the Panamint Range, the belt varies considerably in width and in degree of topographic development. In the southern part of the range the largest remnant of this old land surface is represented by the peculiar depressions known as South Park and Middle Park, which lie at an elevation of nearly 6500 feet, and are drained westward through South Park and Middle Park

[4] Blackwelder, Eliot, Mudflow as a Geologic Agent in Semiarid Mountains. Geol. Soc. Am. Bull., vol. 39, pp. 465–484, 1928.

[5] Ball, S. H., A Geologic Reconnaissance in Southwestern Nevada and Eastern California. U. S. Geol. Survey Bull. 308, pp. 16–17, 119, 161, 202, 1907.

[6] Ferguson, H. G., Geology and Ore Deposits of the Manhattan District, Nevada. U. S. Geol. Survey Bull. 723, pp. 61–62, 1924.

[7] Meinzer, O. E., Ground water in Big Smoky Valley, Nevada. U. S. Geol. Survey Water-Supply Paper 375, p. 90, 1915.

[8] Buwalda, J. P., Tertiary Mammal Beds in West-Central Nevada. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 8, pp. 358–359, 1914.

Canyons. Similar topography characterizes a large area north of Wildrose Canyon, in which the drainage divide lies somewhat south of the center of the area. The country south of the divide is drained into Wildrose Canyon and Panamint Valley, whereas to the north the drainage is through Emigrant Canyon into Death Valley. Owing to the

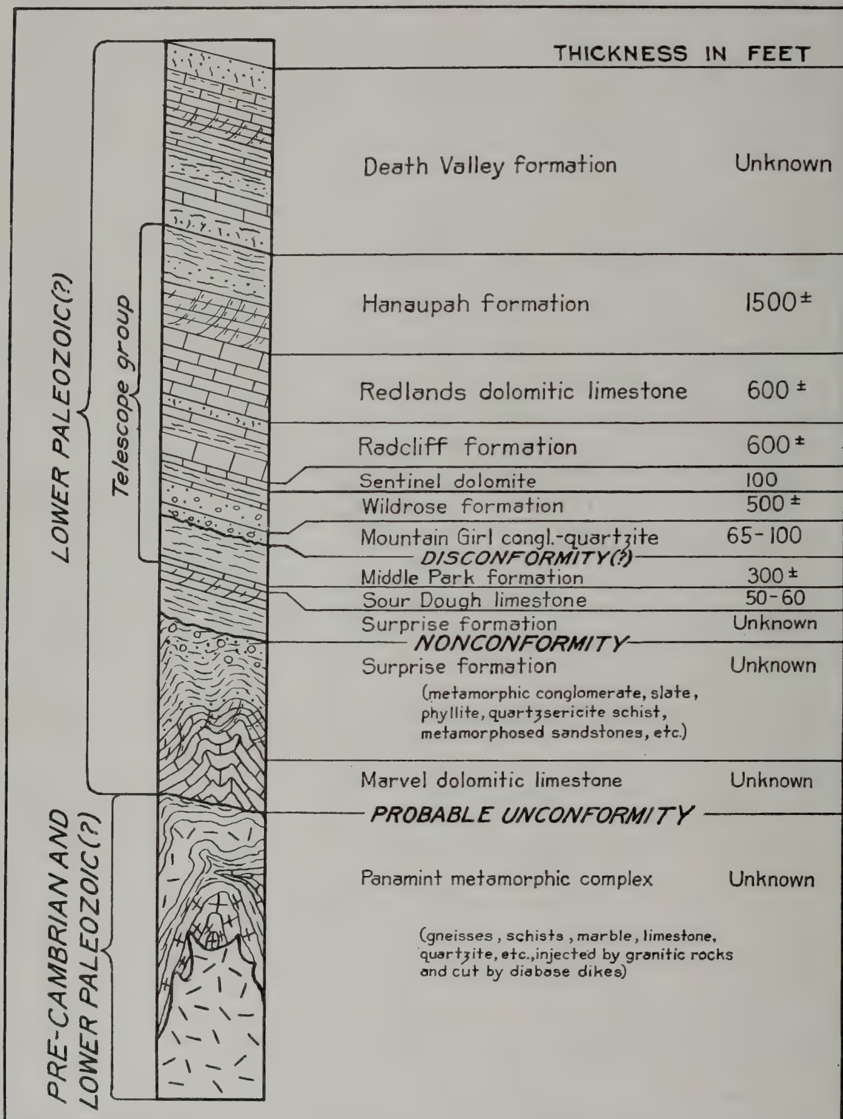


FIG. 3. Generalized columnar section of rock formations in the southern part of the Panamint Range.

absence of Tertiary volcanic rocks in the area studied, this old erosion surface can not be definitely assigned to any particular age, although it is undoubtedly a counterpart of others described in the Basin Ranges, many of which have been considered late Pliocene in age.

STRATIGRAPHY AND PETROLOGY

Summary of Stratigraphic Relations.

Although sedimentary, metamorphic, and igneous rocks are all represented in the area under consideration, the dominant types range from highly metamorphosed paragneisses and paraschists to less greatly altered argillites and limestones. The oldest formation consists of a considerable thickness of undifferentiated and regionally metamorphosed rocks embracing schists, gneisses, and marble of likely pre-Cambrian age. The overlying formations, which appear to be separated by an unconformity, are for the most part less strongly metamorphosed and consist chiefly of dolomitic limestones and slaty schists. Though the ancient crystalline rocks are intensely folded and no regular stratigraphic sequence was recognized, the unconformably overlying formations making up the crest of the range and the eastern slope, dip rather gently eastward. They consist largely of dolomitic limestone, schists, slates, argillites and intermediate facies. Owing to the short time devoted to the study of the Death Valley side of the range, the order of superposition of the various stratigraphic units was not completely determined. In consideration of their lithologic character, these rocks are believed to be of Lower Paleozoic age. It has not yet been possible to correlate any of the rock formations in this part of the Panamint Range with other sections in the general region, and for this reason new formation names are here applied. (Figure 3.)

Panamint Metamorphic Complex.

Distribution and General Features.

The name, Panamint metamorphic complex, is applied to a series of metamorphic crystalline rocks, presumably in large part of sedimentary origin, which occupies a large area in the southern part of the Panamint Range. The prevailing types include biotite-muscovite-quartz schist, quartz-muscovite gneiss, biotite-quartz gneiss, actinolite-biotite-quartz schist, marble, and limestone. The only metamorphic rocks of known igneous origin are sheared granite gneiss and hornblende schist. These rocks have been injected by granite and aplite and cut by diabase dikes.

Gneisses and Schists.

The predominating rocks of the complex are gneisses and schists in which there is much variety in coarseness of crystallization, cleavability, and megascopical appearance. The several intergrading facies vary widely in composition and texture from true gneisses and schists with well-marked foliation, to less highly metamorphosed impure quartzitic rocks, with foliation hardly perceptible. Inasmuch as the formation contains many gradations between coarse gneisses and finer grained banded schists, any description of one variety would not be entirely applicable to another. The following minerals have been identified in these rocks, and occur in various proportions: quartz, muscovite, biotite, microcline, plagioclase (generally albite), orthoclase, microcline-perthite, actinolite, hornblende, epidote, augite, zoisite or clinozoisite, magnetite, titanite, apatite, and zircon.

Briefly, these ancient rocks are so completely crystalline and have been so greatly metamorphosed, that little trace remains of their original components, whether of sedimentary or of igneous origin. In certain rock masses there is definite indication of former bedding. In others this is wholly lacking. The controlling factors are the type of the original rock, the extent of folding, and the degree of metamorphism. The marked change in composition from place to place as well as the lithologic variation across apparent "beds" which range from mere laminae to massive bands, suggests a sedimentary series. Certain lenses and layers are in places found to be parallel to the bedding at contact with other rocks of the series where the alternation of material shows which of these is the plane of stratification. Hence

FIG. 4. An exposure of closely sheeted marble in Surprise Canyon.

such lenses can be provisionally accepted as indications of stratification elsewhere. Furthermore, in places sheared quartzite pebbles, not completely destroyed by metamorphism, indicate the presence of original conglomeratic material.

Under the microscope the manifestation of extreme shearing is the most conspicuous feature of the rocks. This shearing is in a far more advanced stage in some parts of the same rock mass than in others. Severe cataclastic effects are everywhere evident which have resulted in the obliteration of original features. In most of the sections examined it was not possible to recognize the remains of detrital material, although rounded clastic grains of zircon and quartz were observed. Quartz preponderates over all other mineral constituents. This is particularly true of the assemblage quartz, muscovite, and biotite. Calcic minerals are generally absent. These features are strongly

suggestive of the derivation of the rocks from quartzose sediments. Further, the association of these rocks with beds of limestone and marble, and their similarity to metamorphic rocks of known sedimentary origin, strengthens the view that the series as a whole originally consisted of sediments.

Limestone and Marble.

Many of the limestone bodies occur near the west base of the range. They are varicolored but often light-brown to buff on weathered surfaces and of varying degrees of crystallinity. Intercalated schist lenses are not uncommon. The limestones are generally contorted and irregularly banded, light and dark. They are always impure and cherty, and in most exposures finely speckled with sericite.

Extensive areas of dolomitic marble occur in several localities. The rock is massive, fine to medium-grained, white to grayish-white where fresh, and buff to light-brown, where weathered. The rock is frequently characterized by irregular lenticular dark streaks probably composed of carbonaceous matter. Sericite and bladed tremolite are common megascopic constituents. The latter is particularly noticeable along shearing planes. Figure 4 shows the close sheeting of marble in Surprise Canyon.

Sheared Granite Gneiss.

The largest body of an original igneous rock within the Panamint metamorphic complex is a sheared granite gneiss which forms an irregular strip of country near the west base of the range. There is a general uneven distribution of gneissic structure. The development of foliation is more marked in some parts of the rock mass than in others, but the rock is never massive. Metamorphism, however, has not proceeded far enough to obscure its original igneous texture.

The rock is white to gray in color, notably fresh, and in its most typical form is a coarsely banded gneiss, composed of feldspar, quartz, muscovite, and more rarely biotite. The most conspicuous feature of the rock in thin section under the microscope, is the manifestation of extreme shearing. The peripheral shattering and granulation of the large grains has given rise to typical mortar structure of the irregular, interlocking and dovetailing granules. The large feldspars are generally microcline, with whatever crystalline boundary they may have once possessed obliterated by the great mechanical changes they have undergone. Evidently unmixing during metamorphism has resulted in blebs and streaks on the feldspars which prove to be albite. In addition, shearing has produced a very pronounced pressure twinning of the original feldspar crystals as well as marked undulatory extinction. Other primary minerals are orthoclase, albite-oligoclase, and muscovite. Secondary minerals are muscovite, sericite, chlorite, and magnetite with frequent variations in the proportions of these.

World Beater Porphyry (porphyritic granite).

This rock forms a roughly quadrangular area of about 6 square miles, and stretches from Pleasant Canyon to Happy Canyon. The age relations of this mass to the other rocks of the complex are not entirely clear. It is not always easy to draw a definite contact between the

porphyritic granite and the quartz-biotite gneiss with which it is in contact on the west. There is a possibility that the granite and the gneiss grade into each other, and if this be true, the intergradation is probably a result of absorption of the gneiss by the granite when injected. The granite is provisionally regarded as pre-Cambrian.

The porphyritic granite is a coarse-grained gray rock, brownish where weathered, containing fair-sized phenocrysts of potassium feldspar and smaller ones of plagioclase, and in addition biotite, muscovite, and abundant quartz. The rock is decidedly gneissic in places with very irregular streaks of biotite alternating with siliceous streaks containing little or no feldspar. This is especially true near the borders of the mass. Under the microscope the rock exhibits considerable

FIG. 5. Hornblende diabase dike cutting aplite, The Narrows, Surprise Canyon. The dike has a width of about six feet. The walls of the canyon rise vertically for several hundreds of feet at this point.

cataclastic effects. Moreover, these effects vary considerably in magnitude in the few sections examined. The most significant feature is the tremendous shattering of the grains and the subsequent development of biotite, quartz, albite, and muscovite. The feldspars have been given a microperthetic effect due to prominent streaks and blebs. These have probably resulted from unmixing during metamorphism, and their index of refraction would indicate albite. Albite also occurs as a filling around primary orthoclase and microcline.

Aplite.

As dikes and irregular masses, aplite invades the rocks of the complex and attains some local prominence. These aplites are probably

pre-Cambrian in age and may or may not have been intruded prior to the regional metamorphism of the complex. The comparatively slight granulation in them and the lack of metamorphic minerals might indicate a later and feeble dynamic metamorphism.

The typical aplite, as exemplified by the large intrusive body in Surprise Canyon, is snow-white in color and notably massive with megascopic feldspar, quartz, and muscovite. The microscope reveals a medium-grained hypidiomorphic granular aggregate of oligoclase-albite, orthoclase, quartz, microcline, and muscovite, named in descending order of abundance. The rock is rich in quartz in both small and large grains, but the smaller grains are secondary and arranged in typical sutured texture. The large quartz grains show strong to moderate undulatory extinction. Dark minerals are wholly lacking aside from sporadic crystals of biotite. Apatite is an accessory mineral.

Diabase.

Diabase dikes and more rarely sills, occasionally occur, cutting the gneisses, schists, and granitic rocks of the Panamint metamorphic complex. In some places they occupy zones of fissuring or jointing, in others they are injected along the planes of schistosity and as such generally strike north and dip west from 45° to 70°. One of these dikes, cutting aplite, is shown in Figure 5. Striking contrast is shown between the unusual aplite, snow-white in color, and the dark-green diabase, filling a fissure or joint.

The diabase is an aphanitic, fine to medium-grained rock. Microscopically, it consists essentially of augite and labradorite, but in a few dikes green hornblende is an important constituent, paramorphic after a brown to yellow pleochroic variety approaching barkevikite. The minerals are panidiomorphic with medium-crystalline ophitic aggregates in which the usual place of augite is more rarely taken by hornblende. Crystals of olivine, largely altered to serpentine, are occasionally noted. Magnetite and biotite are accessory minerals.

Origin and Structural Features.

Although the sequence of intrusions is, for the most part, unsolved by this reconnaissance, it is apparent that the igneous rocks are not all of the same age. Though intrusive granitic rocks have played their part in local folding and recrystallization, yet the dominant process seems to have been more regional in character, occasioned by deep burial and mountain-making forces. A general uneven distribution of gneissic structure is recognized. Nevertheless, it appears that there has been a more or less uniform result produced by metamorphism in originally dissimilar rocks.

Structure within the complex is not entirely clear and that of certain rock masses is indeterminable. Secondary structures have made it impracticable to recognize any regular stratigraphic sequence, and the highly crumpled condition of many of these rocks, seriously hampers any attempt to unravel their probable complex structural history. The irregularity is perhaps partly original. Several schist and limestone bodies occur in great lenses, which thin to the north and south. The dominant trend of the foliation in any of the schist and gneiss areas of any considerable size, is northward and the dip, from

45° to 70° westward, but considerable deviation from this trend and attitude was seen in other parts of the area. In smaller masses, the strike and dip of the schistose cleavage is often quite variable. It would appear that more often the schistosity is approximately parallel with whatever larger banding, due to differences in composition of the rocks, may be discernable. This would be accepted as an indication that the schistosity is roughly parallel with the original bedding planes of the rocks. However, more detailed work would be necessary to substantiate this view.

The age of this assemblage of rocks is unknown. It is suggested, however, that a highly brecciated and crumpled limestone occupying

FIG. 6. Looking north from a point in Hall Canyon about five miles from its mouth, showing lenticular and interbedded character of rocks of the Panamint metamorphic complex. The light rock is marble and the dark, mica and actinolite schists.

a large lenticular body near the west base of the range, locally bears close lithologic similarity with the Eldorado limestone (formerly called "Prospect Mountain limestone") of Cambrian age.[9] It is very improbable that any of the rocks are younger than Cambrian. In view of the fact that they are largely coarse-textured gneisses and schists, it seems logical to regard them as pre-Cambrian. The fact that the rocks are regionally metamorphosed and in places intensely folded, would tend to strengthen such a conclusion.

[9] Hague, Arnold, Abstract of Report on the Geology of the Eureka District. U. S. Geol. Survey Third Ann. Rept., pp. 253, 254, 1883.

Walcott, C. D., Cambrian Geology and Paleontology. No. 5: Cambrian Sections of the Cordilleran Area. Smithsonian Miscell. Coll. No. 1812, Washington, p. 184, 1908.

Probable Unconformity.

It is here suggested that an unconformity separates the rocks of the Panamint metamorphic complex from the Marvel dolomitic limestone and the Surprise formation, although no direct evidence to support this supposition was obtained. It is difficult to separate the rocks into distinct groups. Their relations have not been closely studied and await interpretation. There exists, however, a striking contrast between the highly metamorphosed coarse-textured gneisses and schists with well-developed foliation, and are locally intensely folded, and the apparently younger formations composed essentially of fine-textured slaty rocks that are probably less highly folded. When two series of rocks occur together, one of which is more crystalline, more intensely folded and more highly metamorphosed than the other, it is a legitimate supposition that the former is older than the latter and is separated by a change in dynamic conditions. This assumes that the two series of rocks are of comparable susceptibility to metamorphism.

Marvel Dolomitic Limestone.

The Marvel dolomitic limestone, named from a branch of Surprise Canyon in which region it covers a prominent area, is essentially a light bluish-gray cherty rock of varying degrees of crystallinity. Tremolite and muscovite are abundant, an unusual feature in a limestone not very highly crystalline. The bedding is greatly contorted in some places and the rock decidedly schistose. Furthermore, it shows irregular mottling, due to brecciation. Suggestions of fine lines of stratification can occasionally be noted in fragments making up the mottled breccia. A partial chemical analysis of crystalline unaltered material gave the following results: CaO — 31%, MgO — 20%.

The contact of the Marvel dolomitic limestone with the overlying Surprise formation is nowhere sharply defined and at no place can be called a normal depositional contact. There is usually a gradation from a true limestone to a true schist for a distance of from 5 to 30 feet. The limestone simulates an intrusive relation to the schist, which suggests a squeezing into the less competent layers of the overlying Surprise formation.

Twelve separate areas have been distinguished in the reconnaissance mapping of this formation. The irregular shape of these limestone areas is probably due to a combination of several causes. The fact that in some places the formation contains interspersed irregular but generally lenticular beds of schist, indicates that the deposition of the limestone was an interrupted process. The several areas represent infolded portions of the Marvel dolomitic limestone which were probably deposited either as a single lens or as a series of lenses. Then followed intense compression and complex folding to such a degree that bedding was almost wholly obliterated, and consequently the structure can not be determined. With the subsequent planing-off by erosion of all the upper parts of the folds and their truncation down to the level of the present surface, it is possible to visualize the shape and distribution of these irregular areas. In many respects, therefore, these limestones are analogous to those of the Calaveras formation of the Sierra Nevada, California, and the Zanzibar limestone of the Manhat-

tan district, Nevada. In a few places where bedding has been recognized, dips up to 45° were measured.

All traces of organic structure have been destroyed. Near the south base of Sentinel Peak, the limestone is made up of oölite-like nodules, which closely resemble those of an Ordovician limestone from the Inyo Range, California.[10] In the absence of diagnostic fossils, the age of the rock is unknown. Tentative assignment to the Lower Paleozoic has been made largely on lithologic grounds, particularly the mottled appearance, high magnesium content, and the intensely folded and often schistose condition of the rocks.

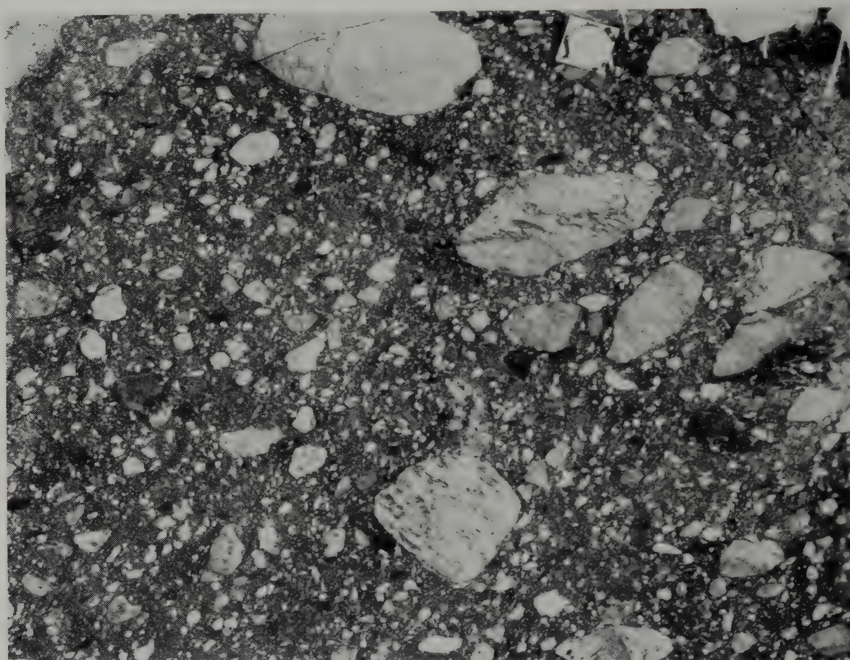


FIG. 7. View showing details of conglomerate schist within the Surprise formation, Panamint mining district. Most of the fragments are limestone but there are some of quartzite. Many of the limestone boulders are themselves conglomeratic and most of them have been sheared.

Surprise Formation.

Distribution and General Features.

The name, Surprise formation, is given to a series of predominantly fine-textured flaggy or slaty rocks which occupy an irregular strip of country on the western side of the range. The most significant feature is perhaps the large number of rock types represented, and there is in consequence a marked change in composition from place to place. Owing to their fine-grained, compact character, few minerals can be identified by the unaided eye. Though undeterminable megascopically, these rocks show rather complex characteristics readily apparent in thin sections under the microscope, and the classification

[10] Material collected by Dr. W. P. Woodring.

of the various facies rests entirely with the microscope. Although most of the rocks are schistose to a greater or lesser degree, this feature is not always marked in the hand specimen and many of them are rather massive. The prevailing rock types are: conglomerate schist, actinolite schist, ottrelite schist, quartz-sericite schist, slate and phyllite, quartz-biotite-tourmaline schist, metamorphosed sandstones and grits, and a relatively few interstratified irregular beds of brown limestone. There exist, however, all gradations and combinations of the above very generalized varieties of rocks making up the Surprise formation. The following minerals have been identified in thin sections: quartz, biotite (brown and green), sericite, muscovite, actinolite, carbonates, chlorite (one or more varieties), hornblende, rutile, titanite, epidote, apatite, tourmaline, clinozoisite or zoisite, ottrelite, staurolite, magnetite, kaolin, plagioclase, pyrite, andalusite (?), carbonaceous matter, and obscure alteration products.

Conglomerate Schist.

A large part of the Surprise formation, is made up of a type of rock which may, with almost equal propriety, be termed either metamorphic conglomerate, conglomerate schist, or more rarely conglomerate slate. The pebbles and boulders vary widely in size, with a maximum of 4 feet in diameter. They are always ill-sorted (Figure 7), and although subangular to angular fragments occur, the generally well rounded elongated forms are more conspicuous. They are of quartzite and of limestone and very rarely of granitic material. In some places limestone fragments predominate, and again those of quartzite may constitute the bulk of the fragments making up the rock in a given outcrop. Many of the limestone boulders are themselves conglomeratic and most of them have been sheared.

The red to brown or black cementing medium is wholly metamorphic and although it varies somewhat in composition from place to place, it is generally a combination of sericite, biotite, muscovite, finely interlocking grains of secondary quartz, and some calcite. Magnetite and pyrite are usually abundant.

Slate and Phyllite.

Slate and phyllite are common members of the Surprise formation, but owing to the gradations in the series, they are here treated together. In color they are dark gray or black, but on weathered outcrops have a more or less rusty appearance. The texture is fine and compact throughout, and the bedding is commonly marked by a fine delicate banding. These rocks generally exhibit a slaty cleavage that is distinct but nearly everywhere less pronounced than the shaly parting, which plays the dominant part in the disintegration of the rocks. Microscopically, the slate and phyllite are made up of irregular and generally elongated grains of quartz embedded in a fine-textured matrix of sericite and other indeterminable impure micaceous materials mingled with minute opaque particles, commonly magnetite and pyrite. The schistose structure is well shown by the arrangement of the elongated and ragged shreds of sericite in a common direction inclined to the planes of stratification. Recrystallization has resulted in the obliteration of primary features.

FIG. 8. View looking north across Surprise Canyon, Panamint mining district. a, Marvel dolomitic limestone; b, Surprise formation; c, Little Chief Porphyry (granite porphyry), here forming the crest of the range. The white band in the background is Sentinel dolomite, a conspicuous marker.

Ottrelite Schist.

In a few specimens a little ottrelite was found, and at several localities this mineral occurs in such quantity that the rock must be called an ottrelite schist. In color the rock is olive-green, with a silvery satiny luster on fresh fracture, and dotted with numerous dark-green oblong plates of ottrelite. In thin section, the porphyroblasts of this mineral occur in comparatively large crystals and sheaf-like forms embedded in a schistose matrix of sericite, quartz, and biotite. Ottrelite is arranged transverse to the foliation, thus indicating that it was developed subsequently to the structure produced in the dynamic metamorphism of the rock. Frequently the mosaic of quartz grains of the matrix, penetrates or cuts across ottrelite crystals, while the sericite of the matrix was absorbed by the ottrelite during its crystallization.

Metamorphosed Sandstones and Grits.

The arenaceous rocks which predominate in the Surprise formation are not uniform in their megascopic appearance from place to place, but are generally fine-textured, rather massive, and gray to brown or green in color. These rocks are found by microscopic study to be composed essentially of detrital grains of quartz, which show little uniformity as to either size or shape, completely cemented by confused aggregates of numerous metamorphic minerals. In some sections the clastic quartz grains are rounded, in others they are subangular to angular, and in still others round and angular grains are equally represented. There is usually no definite arrangement of grains, and the sizes vary widely in even a single section. The complex metamorphic filling is generally a combination of sericite, muscovite, biotite, calcite, and secondary quartz, with actinolite, clinozoisite, tourmaline, plagioclase, magnetite, titanite, and rutile occurring in various proportions.

Other Rocks.

Other parts of the formation are characterized by dark-green knotted schists, some with spots of biotite, and others with numerous dark elliptical areas of complex mineral aggregates. In another type actinolite is abundant, although this mineral is very seldom detected by the unaided eye. Fine-textured gray to brown quartz-sericite schists and quartz-biotite-tourmaline schists are not uncommon in the Surprise formation. Rarely thin beds of brown siliceous limestone occur, and locally the formation is cut by narrow dikes of granite, pegmatite, and hornblende diorite porphyry.

Origin and Structural Features.

The Surprise formation is a rather monotonous assemblage of fine-textured schists and slaty rocks in which it is difficult to single out any distinctive members. The mineralogical composition is not constant qualitatively and quantitatively, and often is very complex, as seen in thin section under the microscope. Nearly all traces of primary sedimentary characters which the rocks may have once possessed are now largely obliterated. In some sections detrital quartz grains have been noted, in others the remains of detrital material are wholly lacking and the rocks entirely recrystallized and reorganized with crystallo-

blastic texture. Moreover, some are typically cataclastic and dynamic action is evinced in the peripheral shattering of the larger grains giving rise to poorly defined mortar structure and marginal reaction effects. Although the detrital quartz grains are ill-sorted and vary widely in size and shape, nevertheless the material may have been uniform in distribution originally. Though bedding is not often seen, in places the original sedimentary structures are still visible and there can be no doubt as to their original sedimentary character. It may thus be regarded as a metamorphosed series of sandstones, grits, shales, and conglomerate, intercalated with thin limestone beds.

Although in general the schistosity of the rocks strikes north and commonly dips at high angles, yet the angle between directions of

FIG. 9. The Telescope group of rocks as seen from a point in Hall Canyon. Telescope Peak at the extreme left is 3500 feet above the observer.

schistosity and bedding varies widely from place to place. Frequently, the schistosity is normal to the contact of the Surprise formation with the Marvel dolomitic limestone. The Surprise formation contains rocks of various kinds, but folding, faulting, and metamorphism have made it impracticable to recognize any regular stratigraphic sequence.

Telescope Group.

General Statement.

The names of the eight members which comprise the Telescope group of rocks, together with their thicknesses and the order of their succession, are graphically summarized in the accompanying columnar section (Figure 3). The names of these formations are derived from

geographic terms used in this part of the Panamint Range. The section is well exposed naturally (Figures 8 and 9), but owing to the ruggedness of the country, only parts of the section were studied in detail. Although most of the formations, in general, are rather well-individualized units, the precise horizons for the division planes that separate them are often matters for arbitrary decision. There is a fairly wide lithologic variation from place to place and only the most distinctive features of each stratigraphic unit are presented in the following table. The rocks have nearly all been metamorphosed to some degree and in the absence of diagnostic paleontologic evidence the age of all formations is open to question. Tentative assignment to the Lower Paleozoic has been made largely on lithologic grounds.

The Surprise formation is separated from the Telescope group of rocks by a nonconformity. Though the structure could not be determined in either the Marvel dolomitic limestone or the Surprise formation, the rocks of the Telescope group are undeformed and have an easterly dip of from 10° to 30°. Some of the rocks are now entirely recrystallized, nevertheless the change has not greatly obscured their original structure, lamination, and relations. The strike and dip of the schistose cleavage always coincides with the bedding planes.

Table of the Telescope Group of Rocks

	Thickness in feet
8. Hanaupah formation.	
Predominantly fine-textured slaty or flaggy rocks, generally with an irregular lumpy fracture. Quartz-biotite schist with irregular streaks of sericite, finely banded with gray, green, or chocolate-brown, thin, lenticular, and generally corrugated stripes; regularly banded, micaceous schist with megascopic tourmaline and magnetite, and characterized by small oval dark-green spots; flaggy rock in which epidotized stripes alternate with finer ones of light-colored arenaceous and calcareous material; and a few beds of white to pink quartzite.	1500±
7. Redlands dolomitic limestone.	
White, crystalline, cherty dolomitic limestone in which bedding is not readily recognized. Probably occurs as a lenticular body.	600±
6. Radcliff formation.	
Chiefly flaggy, corrugated, impure, arenaceous limestone, gray where fresh, reddish-brown where weathered, intercalated with a dark-gray thinly banded lime-silicate rock containing muscovite, biotite, diopside, epidote, zoisite, vesuvianite, and abundant pyrrhotite; also gray and white sandstones; gray and white mottled crystalline limestones; and finely striped gray and green slate and phyllite.	600±
5. Sentinel dolomite.	
White, slightly arenaceous bed of dolomite, characterized by irregular patches or segregations of coarsely crystalline carbonates or more rarely chert.	100

	Thickness in feet
4. Wildrose formation.	
Largely conglomerate quartzite with widely scattered elongated pebbles up to 4 inches in diameter of quartzite, granite, and granite gneiss in a dark-gray to black matrix of round to angular quartz grains, completely cemented by complex metamorphic aggregates; also finely banded, brown to gray biotite schist and some crystalline limestone.	500±
3. Mountain Girl conglomerate-quartzite.	
Apparently a persistent formation consisting of 10–25 feet of reddish-brown conglomerate with well-rounded pebbles up to 14 inches in diameter of quartzite and rarely of limestone, grading into a rather massive rock containing allothigenous quartz grains in a cementing medium of sericite, chlorite, muscovite, biotite, and ferruginous material.	65–100
(Disconformity?)	
2. Middle Park formation.	
Fine-textured dark-gray quartz-biotite schist, spotted schist, green ottrelite schist, and dark-gray impure metamorphosed quartzitic rocks.	300±
1. Sour Dough limestone.	
Crystalline micaceous arenaceous gray limestone, with alternating white and gray stripes that in some places are corrugated. (The oldest formation of the Telescope group.)	50–60
Total	3,700+

Death Valley Formation.

Distribution and General Features.

The name, Death Valley formation, is given to a considerable number of interbedded limestones, argillites, and schists which occupy the east flank of the range. Little time could be devoted to this large area and the present descriptions are necessarily sketchy. If there is any ascertainable stratigraphic sequence, it is still unknown. The interbedding of rocks which do not vary greatly in lithologic details would probably seriously hamper an attempt to separate the Death Valley formation into mapable units. Moreover, the rocks are apparently nonfossiliferous. Lithologically, they are not greatly unlike those of the Telescope group, and are in marked contrast to the more highly metamorphosed gneisses and schists of the Panamint metamorphic complex. In general, these rocks are questionably referred to the Lower Paleozoic.

Though there are local westerly dips, the beds as a whole have a general easterly dip of from 5° to 45°.

Calcareous Rocks.

The great bulk of the formation consists of generally thin-bedded calcareous rocks which may either be called impure siliceous limestones or calcareous argillites. Some rather pure crystalline limestones also occur and rather heavy-bedded varieties are not uncommon. The colors represented are white, gray, brown, and intermediate hues. Though some limestones are striped with fine bands, generally brown in color; others are spotted with small flakes of muscovite or blotched by ferritic material. One limestone is characterized by irregular patches or segregations of coarsely crystalline carbonates, another by siliceous laminations which parallel the bedding. Though the bedding and banding are generally regular, they are corrugated in many places.

Argillaceous and Arenaceous Rocks.

In general, the limestones are intercalated with rocks which may variously be called argillites, slates or shales. They are generally thin-bedded or striped slaty rocks, gray to brown or green in color, and either with or without distinct slaty cleavage or shaly fracture. The banding may be either regular or corrugated. Ordinarily no minerals are visible to the naked eye but in certain types biotite, sericite, muscovite, magnetite, pyrite, and quartz can be identified.

One distinctive rock is characterized by narrow, lenticular, and generally corrugated light-colored stripes, which alternate with wider layers of dark-green or chocolate-brown color. In places such stripes give a moire effect to a weathered surface of a flag.

Other typical members of the series include obscurely banded sericitic phyllites or schists of brownish-gray color and impure brownish weathered quartzite. Locally the formation is cut by diabase dikes and sills.

Post-Paleozoic Igneous Rocks.

Little Chief Porphyry (granite porphyry).

The stock of granite porphyry which forms the crest of the range near the head of Surprise Canyon (Figure 8) is intrusive into the Telescope group and may possibly be bounded in part by faults. It is a massive, medium-grained pink rock whose megascopic constituents are orthoclase, plagioclase, and quartz, speckled with small black prisms of hornblende. Under the microscope the essential minerals, named in order of apparent abundance, are orthoclase, microcline-perthite, quartz, albite-oligoclase, hornblende, and biotite. The texture is porphyritic with relatively large phenocrysts of microcline-perthite and orthoclase in a microgranitic groundmass. The pale-green, almost colorless hornblende, occurring in comparatively small idiomorphic crystals, is characterized by streaks of brown that have probably resulted from leaching. Apatite, magnetite, titanite, and muscovite are accessory minerals.

Dikes.

Hornblende diorite porphyry dikes cut the Marvel dolomitic limestone, Surprise formation, and the rocks of the Telescope group. Therefore the dikes were intruded subsequent to the folding of these

Photo by J. P. Buwalda.

FIG. 10. Panamint Valley fault scarp, showing remnants of alluvial fans deposited before the more recent faulting took place. View from a point several miles south of Ballarat.

older sedimentary formations. The dikes are rather inconspicuous, ranging in width from 2 to 15 feet with an average of about 5 feet. They have a general strike of from north-south to northwest-southeast and dip from 70° to vertical. Many of them are continuous for a distance of nearly a mile. The color of the freshly fractured rock is olive-green. Prisms of hornblende, where present, represent the only mineral visible to the naked eye. Its decomposed character prevents its being classified satisfactorily. The groundmass is holocrystalline and consists essentially of hornblende and plagioclase. The prevailing green color of the rock has resulted from the epidotization of the feldspar. Augite is present in some sections. Clinozoisite, biotite, chlorite, and interstitial quartz are secondary minerals.

FAULTING

More than one period of faulting was involved in the production of the west escarpment of the range, and the more recent movements are recorded by scarps in the fresh alluvial fans and talus patches at the base of the cliff. The rocks which form the lower part of the escarpment are everywhere tremendously sheared and brecciated. Moreover, the tilting of the Panamint block toward the east is particularly well shown in the east-slanting Lower Paleozoic rocks which form the higher parts of the range. Many interesting features in connection with this faulting have previously been recorded by Noble [11] and Davis.[12] The subject was not studied in detail by the author and only a few significant features of the complex structural history of the range will be mentioned. Its western flank is here unusually steep and rugged, and the escarpment of the range displays a remarkable development of triangular facets, so recently formed that new talus cones are just appearing along the base of the precipitous slope. In this connection it is interesting to note that, although Hall Canyon is 8 miles long, it has a very insignificant fan which is no larger than the fans of many mere gashes. Consequently, one has some difficulty in a drive along the base of the range in locating this, a major canyon of the range. Other similar examples of canyons south of Ballarat are at once brought to the attention of a passing observer (Figure 10).

Thus, while many of the large pre-faulting fans have been completely buried under post-faulting alluvium, a mile or more north or south along the escarpment these old fans have not been entirely depressed. The best example of this is in the large fan at the mouths of Tuber and Wildrose Canyons. Here recent faulting has produced a large and well-defined trench which runs across the fan near its apex (Figures 11 and 12). The feature is undoubtedly a graben, although in keeping with the structural history of the range, may have had a complex history. However, the most outstanding feature is the abrupt truncation of prefaulting fanglomerate just south of Ballarat which has given the deposit a peculiar mesa-like appearance. Its flat-topped surface rises nearly 500 feet above the valley floor. It seems proper to regard it as a remnant of the fan from Pleasant Canyon that

[11] Noble, L. F., The San Andreas Rift and Some Other Active Faults in the Desert Region of Southeastern California. Carnegie Inst. Wash. Yearbook, no. 25, pp. 425–428, 1925–1926.

[12] Davis, W. M., The Rifts of Southern California. Amer. Jour. Sci., 5th Ser., vol. 13, pp. 57–72, 1927.

has been cut off by an oblique fault which probably runs in a southwesterly direction from near the present mouth of Happy Canyon.

In the enormous thickness of fanglomerate, of such remnants of prefaulting fans as exist, dips up to 45° either west or east are not uncommon. Moreover, unconformities in fan material have been noted in several places.

The remarkably steep front frequently persists to the very base of the cliffs and in places the playa-flat, occupying the deepest part of Panamint Valley, lies directly against the escarpment. As has already been suggested, the range is not bounded by one continuous fault, and as Noble has pointed out

> "* * * rather, a succession of faults, each of which is offset from the other along the strike. Consequently their escarpments [of both the Panamint Valley and Death Valley Faults] have a roughly zig-zag pattern and are indented by great concave bights or cusps where the offsets occur. At some

FIG. 11. View looking north along fault-trench, from a point on the western escarpment about four miles south of Wildrose Canyon. The trench is nearly a mile wide and four miles long and is composed of old Quaternary alluvial deposits. It crosses the prefaulting alluvial fans of Wildrose and Tuber Canyons near their apices.

> places the bights mark cross-faults; at others they appear to represent areas of great and sudden downwarp. At many places the faults exhibit enormous changes in amount of throw in distances of a few miles."[13]

The escarpment reaches a probable maximum of 40° as measured on the nose 6 miles north of Ballarat, in the vicinity of the Indian Ranch. All the faults which bound the range, wherever the writer has seen them, are normal and dip west at angles ranging from 60° to 90°. No evidence was obtained to support the view that the approximately 35° slant of the rock-faces may approach that of the dissected fault-plane.

Faulting, with the exception of the recent border faulting on the west front of the range, is probably not an outstanding feature of the

[13] *Op. cit.*, p. 427.

structure of the area as a whole. Although minor faults of small displacement are numerous, the writer did not consider it practical to represent them on the map (Plate IV). Most of the faults are normal and have a prevailing northerly trend.

CONCLUSIONS

The essential geologic features of this part of the Panamint Range have been set forth in some detail in the body of the paper and summarized in the abstract. Although this reconnaissance study has failed to disclose anything of very unusual or striking significance, certain features have come to light which have particular interest because of their relation to broader geologic problems.

The region is characterized by extreme topographic contrasts and by many youthful physiographic features. Attention has been called to the preservation of an old erosion surface in this part of the Panamint Range, which is undoubtedly a counterpart of similar topographic forms that have been preserved in other Basin Ranges. The Panamint Range is a particularly good example of fault-block structure inasmuch as the mountain-making movements have continued into such recent times that the offsets produced in the faulting are plainly evident in the present topography. They are normal faults and dip west at angles ranging from 60° to 90°. Moreover, the north-south structures which characterize that part of the Great Basin lying north of the Garlock fault is well shown in the Panamint Range.

It has not yet been possible to correlate any of the rock formations in this part of the Panamint Range with known sections in the general region. It has been necessary, therefore, to apply local geographic names to the formations herein described. The older rocks are greatly sheared and the highly crumpled condition of certain rock masses has made it impracticable to recognize any regular stratigraphic sequence. This is due, in part at least, to the fact that several schist and limestone bodies occur in great lenses. It is impossible to retrace all of the changes through which these rocks have passed or determine each step in the probable complex history of their metamorphism. The dominant process seems to have been regional in character and very little contact metamorphic effects have been noted. In a large measure also, the folding is attributed to the forces attending regional metamorphism. In general the aplitic rocks show little deformation. The older rocks on the west slope commonly show a westward dip of the foliation, whereas the younger formations, forming the crest of the range and the Death Valley side, in general dip gently eastward. Although diligent search has been made, no definitely determinable fossils have been found and consequently the tentative assignment to the Lower Paleozoic is based wholly on lithologic considerations.

FIG. 12. Northwesterly view from the summit of Telescope Peak, showing the well-defined trench or graben, gashed across

MINERAL RESOURCES OF A PART OF THE PANAMINT RANGE*

By R. J. SAMPSON, Mining Engineer

Location and General Features.

The Panamint range of mountains is in the southeastern portion of Inyo County. It forms the divide between Death Valley on the east and Panamint Valley on the west. Its axis has a northwesterly trend and it extends from the Fifth Standard Parallel South some 80 miles northwesterly. Elevations at the base of the mountains range from 1000′ to 1100′, although the eastern slope goes down to the floor of Death Valley where the low point is 296′ below sea level. Elevations along the crest are from 4000′ to 9000′, culminating in the top of Telescope Peak at an altitude of 11,045′.

The climate is extremely arid, the average rainfall for a nine-year period in Death Valley being 1.71 inches.[1] A temperature of 134° F. was recorded at Greenland (Furnace Creek) Ranch in Death Valley in the month of July. This "is the highest natural-air temperature that has been recorded on the earth's surface by means of a tested standard thermometer exposed in a standard ventilated instrument shelter."[2] While in the mountains the rainfall is greater and the temperature lower, no official records are available. Considerable snowfall may be expected in the upper reaches of these mountains in normal winters. Drainage is into the Panamint and Death valleys, which are both closed basins.

The mineral deposits described herein lie between Wildrose Canyon on the north and an east-west line some two miles south of South Park Canyon. Both of these canyons are on the western slope of the range. The area is roughly 20 miles long by 15 miles wide—its southern end being approximately 15 miles north and slightly east of Trona.

The deserted towns of Ballarat and Panamint are both included in this area. Ballarat is at the western base of the range at an elevation of 1067′, while Panamint is high up on the western slope, elevation about 7500′.

The district is accessible by passable road from Trona. This road crosses the Slate Range at an elevation of about 3000′, some 13 miles north of Trona, thence into Ballarat. From Ballarat, roads lead both north and south in Panamint Valley. Mining properties are reached over branch roads into the various canyons.

History.

The following statement is made by F. M. Murphy:[3] "Chalfant[4] states that in 1858 Mormon emigrants found silver ledges in the Pana-

* This economic report supplements the foregoing geologic report by F. M. Murphy. Many of the notes herein compiled are quoted from that author's more elaborate, unpublished thesis on this area.

[1] U. S. G. S. Water Supply Paper 578, p. 81, 1929.

[2] *Idem*, p. 70.

[3] Murphy, F. M., Unpublished portions of a thesis submitted to the Balch Graduate School of the Geological Sciences of the California Institute of Technology.

[4] Chalfant, W. A., The Story of Inyo; Chicago, The Author, 1922.

mints and built a small furnace south of the town of Panamint. According to a statement by Dr. S. G. George, appearing in the Panamint News of March, 1875, the first person who recognized the mining possibilities of the Panamint district was a Mr. William Alvord in or about 1860. Dr. George, who was a famous Indian fighter of Inyo County, figured in the first actual mining developments of what was then known as the Telescope mining district. Due to Indian outbreaks, the project was abandoned about the year 1862.'' It was some twelve years later that Senators John P. Jones of Nevada and William Stewart of California, together with Trenor W. Park, organized the Panamint Mining Company and real mining development began. Many other companies were formed, most of which were eventually consolidated into the Surprise Valley Mill and Mining Company. During the years of this activity Panamint was a prosperous mining camp with some 2500 inhabitants.

In recent years the decline in the price of silver has brought to a standstill the mining industry in the immediate vicinity of Panamint. Advance in the price of this metal, coupled with the application of the flotation process for recovery of the values in the ore might lead to the successful revival of this district.

Present activity is centered in the gold mines of the area and is largely confined to development and prospecting.

Mineral Deposits.

To the present time the silver deposits of the district have been the most productive, although antimony, copper, gold, and lead have also been produced commercially. Gold seems to be the most widely distributed metal, it having been found in almost all parts of the district. However, few outstanding gold mines have been developed to date. The principal ones are the Burro, O. B. Joyful, Radcliff, and World Beater. Present activity consists largely of development work which is described under the names of the various mines.

ANTIMONY

Depressed market conditions and cheap production of this metal in China have in recent years caused cessation of operations at most properties in this county.

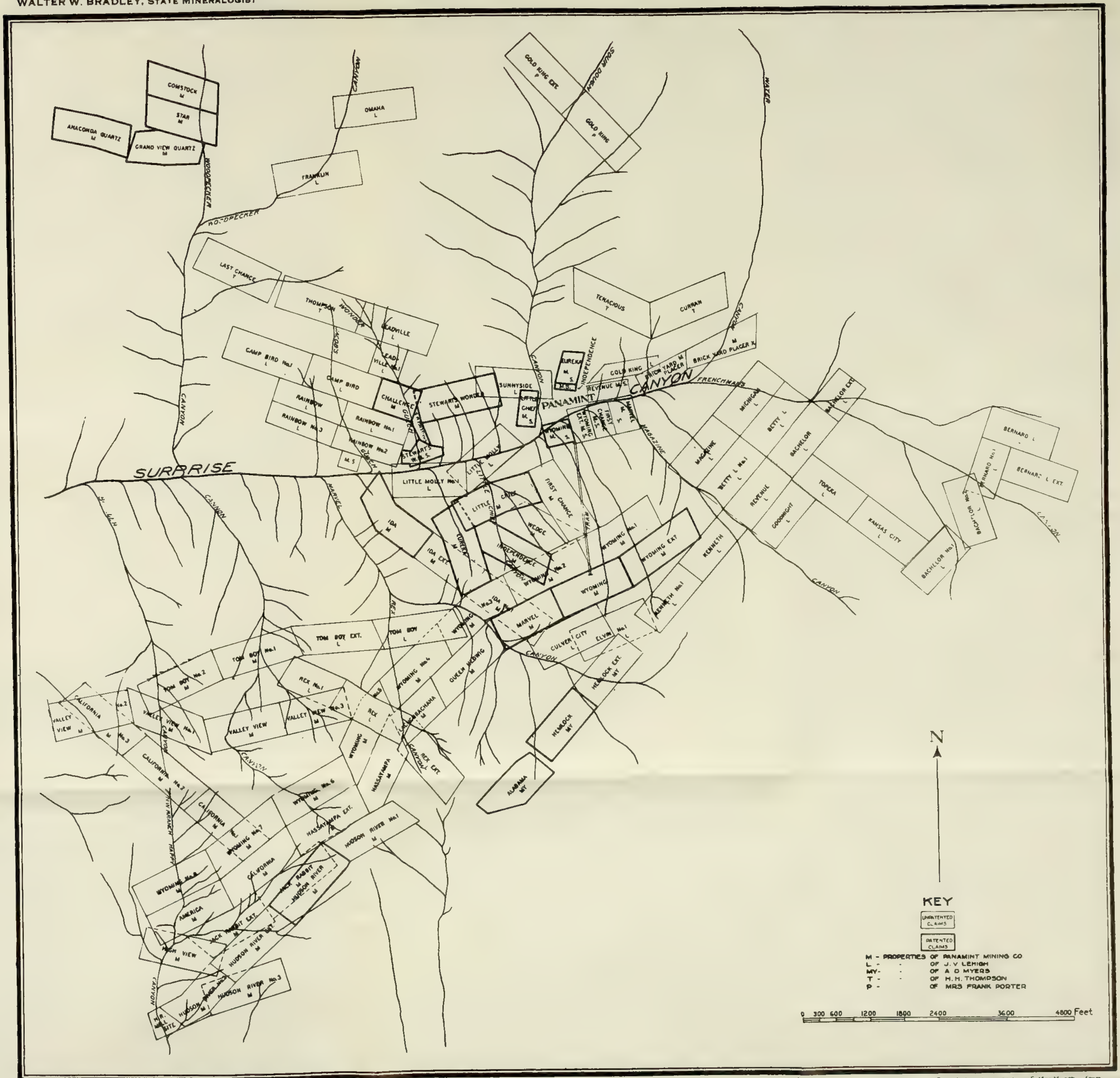
Wildrose Mine, comprising 4 patented claims and several others held by location, is on the west slope of the range in Wildrose Canyon, at an elevation of 5000′. Owner, Western Metals Company, 111 West 7th Street, Los Angeles; M. Elsasser, president.

Irregular veins of stibnite, varying in width from a few inches to over a foot, are deposited in schist. The general trend of the stringers is east and west and their outcrops can be traced for several thousand feet along the ridge. Development consists of opencuts and tunnels.

Ore shipped from the property during the period, 1915 to 1919 is reported to have averaged 35% antimony.

The mine has been idle since 1919.

Bibliography: State Mineralogist's Reports XII, p. 21; XV, p. 60; XXII, p. 462; XVII, p. 273.



CLAIM MAP OF THE PANAMINT DISTRICT, INYO COUNTY, CALIF.

Compiled and revised by F. MacMurdy from various old maps of the district. Positions of claims are largely approximate. 1927

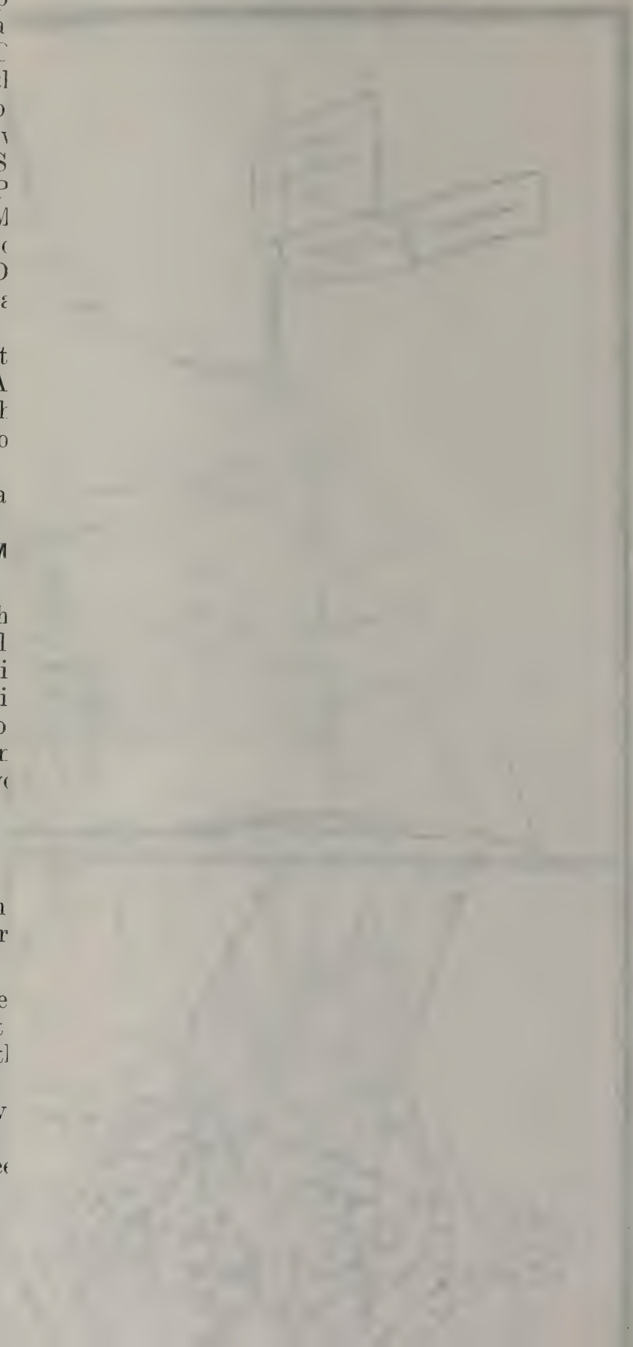
n
p
a
C
tl
b
tv
S
P
M
cc
D
ca

st
A
th
to

la

M

th
al
di
di
to
an
wc



in
pr

he
at
7tl

ov
is
fee

is

COPPER

Copper occurs in the district only as an associate mineral with gold, silver, or lead and any production has been as a by-product from an ore whose principal value was in one of these metals.

San Rafael Group is located on the west slope of the range, one mile north of Tuber Canyon and 40 miles by road north of Trona.

It is reported that on the contact of schist and a porphyritic rock, there occurs a quartz ledge, some twelve feet in width, samples from which assay 21% lead, 7% copper and 4 ounces of silver per ton. Idle.

Bibliography: State Mineralogist's Reports XV, p. 74; XXII, p. 465.

SILVER-LEAD

As the production of lead from the district has largely been due to its association with silver ores, these two metals are here grouped together.

In the past the production of silver from the district has been by far its greatest asset. No actual figures on production are available but it appears probable that something over $2,000,000 in silver and a small amount of lead has been mined in the district. Practically all of this production has come from an area of about three square miles in extent, the approximate center of which is marked by the town of Panamint.

Bachelor No. 2 Mine (formerly known as *Sunrise*) is about one mile east of Panamint town site, near the head of Surprise Canyon. Owner, J. V. Lehigh, 307–9 Union League Building, Los Angeles.

The following statement is made by F. M. Murphy:[5]

"* * * reports indicate that a few hundred tons of high grade silver ore was taken out. It is quite evident that the mine has been entirely worked out.

"From a brief examination it would seem that the ore occurred in a brecciated zone between two parallel fissures with well-defined walls which dip in opposite directions and apparently join to the south in a shape not unlike that of the bow of a boat. The country rock is the Marvel dolomitic limestone. All of the ore was found near the surface and under less than fifty feet of cover. The ore was stoped for a distance of about 100 feet."

Camp Bird Mine (formerly known as *Jacob's Wonder*) comprising the Camp Bird and Rainbow groups, consists of 10 claims. It is in Jacob's Gulch about one mile west of Panamint. Elevation 7300.′ Owner, J. V. Lehigh, 307–9 Union League Building, Los Angeles.

Two quartz veins, the Stewart Wonder and Rainbow, varying in width up to 15,′ here occur in the limestone. Stewart Wonder vein strikes N. 75° W.; dip vertical. Rainbow vein has an easterly strike and dips about 30°–35° to the north. These two veins form a junction near the Jacob Wonder workings.

Development consists of a crosscut tunnel driven north 25′ and a drift east and west for a total distance of 400.′ From this tunnel level a winze has been sunk to a depth of 150′ on the vein.

[5] *Op. cit.*

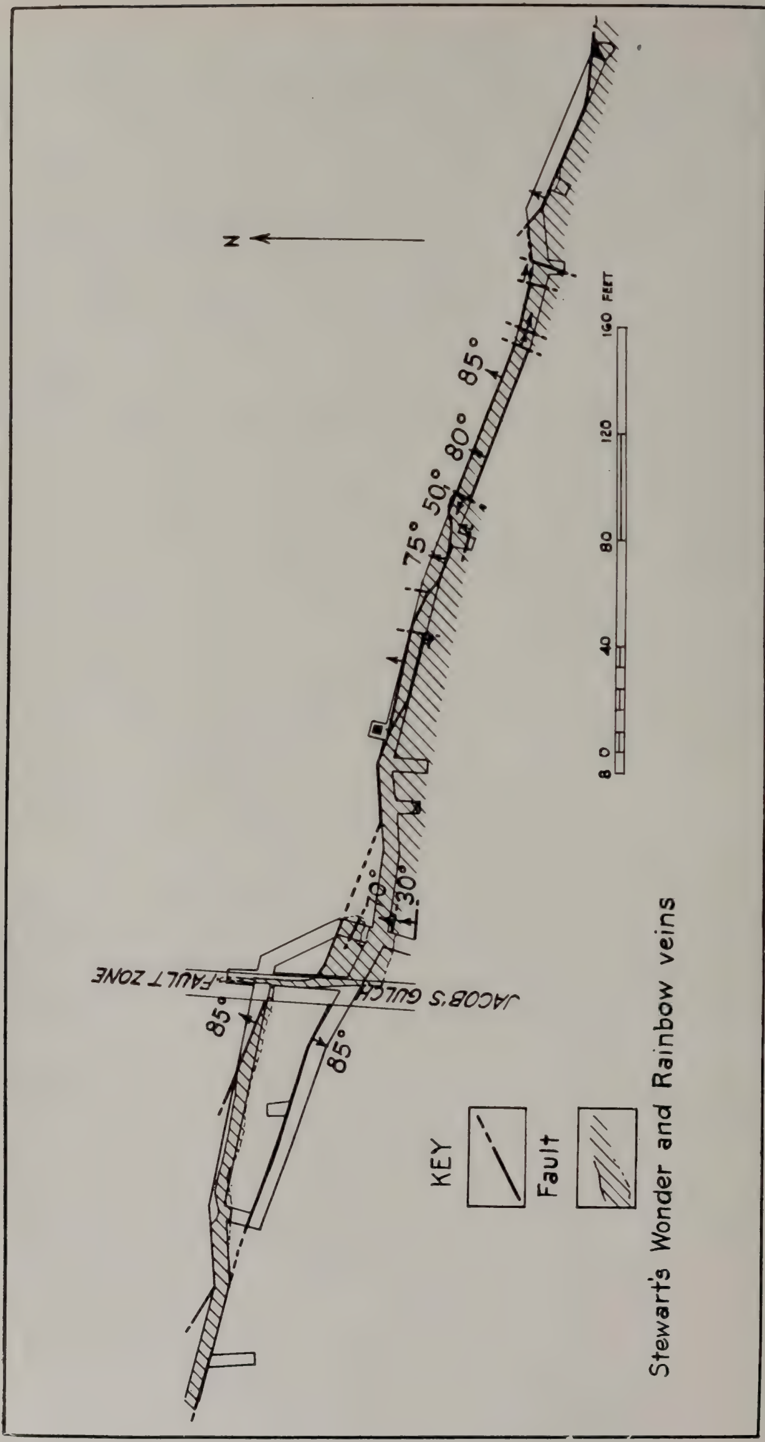


FIG. 1. Plan map of the Camp Bird mine. (*After F. M. Murphy*)

Little or no ore has been stoped. The pay streaks are small and not persistent. The silver mineral contained in the ore is freibergite, a sulph-antimonide of silver and copper. While some specimens of high-grade ore have been found, it is reported that tests of screenings from the dump show approximately $15 per ton.

Idle.

Bibliography: State Mineralogist's Report XXII, pp. 479–480: Unpublished portions of a thesis by F. M. Murphy.

Carbonate Mine (Queen of Sheba) consists of 9 claims on the east slope of the range, about forty miles northeast of Zabriskie, a station on the Tonopah and Tidewater Railroad. Elevation 1200′. Owner, *New Sutherland Divide Mining Company*, 477 Mills Building, San Francisco; John Salsberry, secretary and manager.

The country rock is limestone which has been greatly faulted and cut by intrusions of diorite. The ore occurs as replacement orebodies in the limestone, being principally carbonate of lead with some galena, and it is deposited in irregular lenticular masses along a fault plane. The width of the ore varies from 3′ to 15′. Trend N. 30° E. It is said to average 15% lead and 8 ounces silver per ton. The ore shipped from the property averaged 35% lead and 15 to 20 ounces of silver per ton. It has been worked periodically since 1914.

Development consists of three tunnels. Upper tunnel 60′ below the outcrop is 100′ long; 30′ below is the second with a length of 400.′ A fourth tunnel was started at a lower elevation to tap the orebodies which had been worked in the upper tunnels.

Idle.

Bibliography: State Mineralogist's Reports XV, p. 89, 90; XVII, p. 286; XXII, p. 480.

Chesamac Mine (Lead-silver). It comprises 6 claims on the east slope of the range, 18 miles northeast of Ballarat.

A series of narrow, parallel veins in the limestone are reported to carry high values in silver.

Development consists of shallow tunnels and opencuts along the outcrop. Owners, Donald MacDonald and associates of Los Angeles.

Idle.

Bibliography: State Mineralogist's Report XXII, p. 482.

Gibraltar Mine (Lead-silver) is in the South Park District, 7 miles southeast of Ballarat. Elevation 7000.′

The ore occurs as irregular lenses of lead carbonate and galena in limestone. Shipments are said to have carried 30% lead and 20 ounces of silver per ton.

Idle.

Bibliography: State Mineralogist's Reports XV, p. 95; XXII, p. 485.

Panamint Mines (Silver). The principal mines of this group are the Hemlock, Stewart Wonder, Tom Boy and Wyoming. They are situated in Surprise Canyon, just west of the town of Panamint. Elevation from 6500′ to 8300.′ Owner, A. D. Myers, Los Angeles.

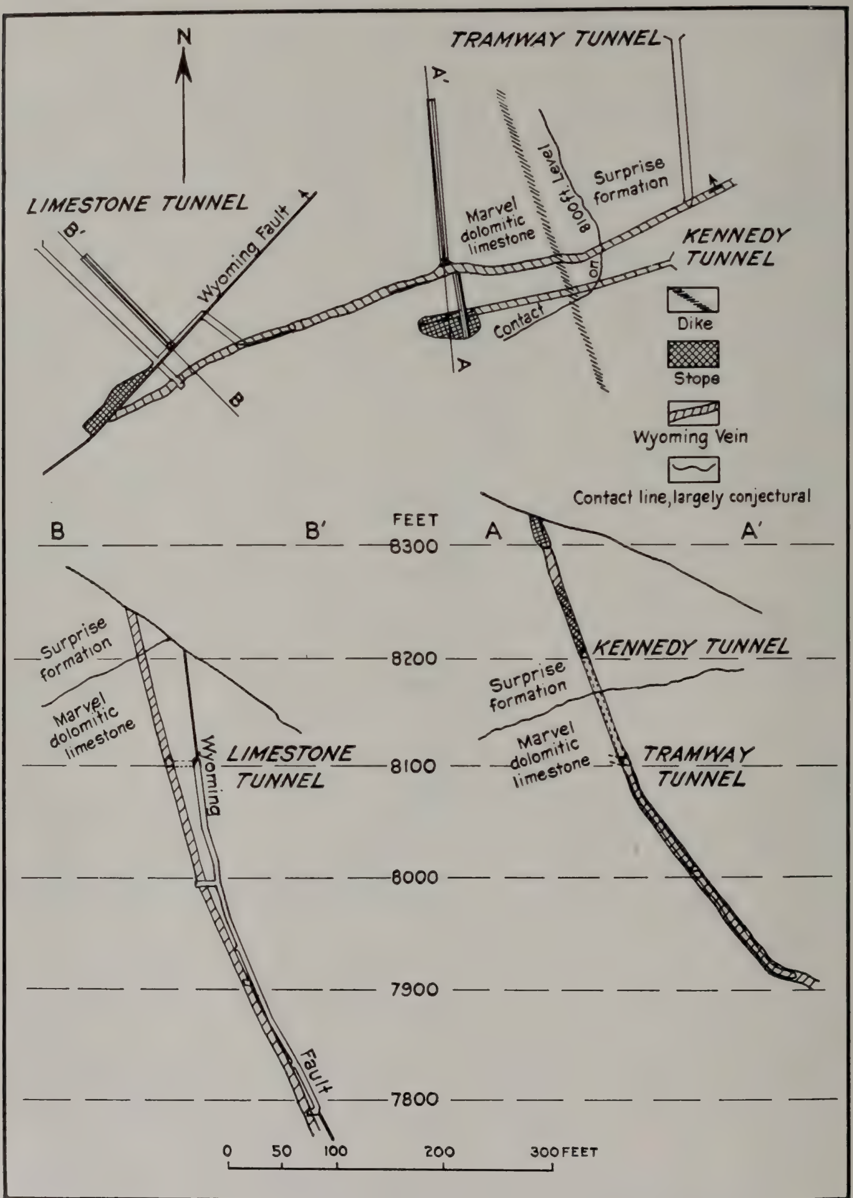


FIG. 2. Plan and sections, principal workings of Wyoming Mine. (*After F. M. Murphy*)

Formerly owned by Panamint Mining Company; E. G. Lewis, president. This group includes most of the important past producers in the Panamint District.

The following description is taken from State Mineralogist's Report XXII, p. 495 and notes by F. M. Murphy.[6]

Hemlock Mine (Silver Peak), locally reported to have been the largest producer of the district, is situated near the head of Marvel Canyon about one mile south of the town of Panamint.

A vein of quartz 6′ to 8′ wide occurs in limestone, strikes northeast and dips 70° NW. The vein has been developed by a number of tunnels driven at different elevations. The lower tunnel is a crosscut driven 150′ to the vein with drifts on the vein for a distance of 500.′

A road connects it with the aerial tramway at the Wyoming Mine by which means the ore was transported to the mill at Panamint. The vein is supposed to be the southwestward extension of the Kenneth vein and the country rock is the Marvel dolomitic limestone and the Surprise formation.

Stewart Wonder Mine (from F. M. Murphy's notes). "The Stewart's Wonder Mine, situated on the north side of Surprise Canyon a short distance west of Panamint town site, includes two patented mining claims, Challenge and Stewart's Wonder. * * * As far as could be learned, all the development work on the property was done during the early days of the camp and includes three tunnels, also several raises, winzes and opencuts on the Stewart's Wonder vein on the east slope of Wonder Gulch, aggregating several hundred feet. * * * It was one of the principal mines of the district but production figures are not available. According to Stetefeldt[7] some of the ore assayed over $900 a ton (probably largely in silver) and the average ore from a pay streak in an incline assayed $83.24.

"The vein, as mapped, boldly outcrops for a distance of 2400 feet, but probably extends about one thousand feet west of the area mapped. It ranges from 4′ to 8′ in width and dips from 80° N. to vertical. The country rock is the Marvel dolomitic limestone. The vein splits into three branches as it enters the Surprise formation and can not be traced more than two hundred feet beyond the contact.

"The west slope of Wonder Gulch has been broken by a number of faults, the more important of which are indicated on the detailed map of the district. These fissures are so numerous that the limestone in the fault zone is much fractured and crushed. They have cut and displaced the vein into several segments and have also resulted in considerable rotation of the vein. West of Wonder Gulch the strike of the vein is N. 70° W. while east of the gulch the strike is N. 64° E. West of the gulch the vein has been badly crushed and in places both walls are followed by faults with more or less brecciation. The faults along the vein are probably an adjustment due to the several cross-fissures."

Wyoming Mine is situated on the south slope of Surprise Canyon, about one-half mile south of and about one thousand feet above the town of Panamint.

---

[6] *Op cit.*

[7] Raymond, R. W., Mines and Mining in the States and Territories West of the Rocky Mountains for 1875, p. 37, 1877.

The country rock consists of limestone and schist. The vein system comprises a series of parallel quartz veins 6′ to 8′ wide that trend northeast and dip 60° to 70° to the northwest. Of these several veins, only the Wyoming has been productive. It is easily traceable over a fairly straight course for more than 3500′. Its width is up to 8′, probably averaging about 4′. It is generally wider and more persistent in the limestone where also occurs the principal mineralization. This limestone belt is about one-half mile wide, having a northwest-southeast trend. The vein quartz is mineralized with tetrahedrite and stained with bromides of silver, azurite and malachite.

The mine was developed by four tunnels. The lower one of these, elevation 7100′, is a crosscut 2310′ long which did not intersect the vein. It is about 1000′ below the outcrop and 680′ below the bottom of a winze which was sunk 200′ below the Limestone tunnel. The Limestone and Tramway tunnels were driven south at an elevation of 8100′. They are both crosscuts to the vein. The Kennedy tunnel was driven southwesterly some 250′ at an elevation of 8200′. It is on the vein. Most of the ore came from two stopes, one at the end of the Kennedy tunnel and one in a drift of the Limestone tunnel. In the Limestone tunnel a drift was driven southwesterly 200′. At 150′ south of the crosscut there is a raise to the surface, a distance of 100′ and a winze on the vein was sunk 200′ below this tunnel. Total workings aggregate about 2500′, exclusive of the long crosscut tunnel (Lewis tunnel).

The ores were formerly treated in a 20-stamp mill at Panamint. An aerial tramway from the Wyoming Mine carried the ores to this mill. This tramway was reconditioned in 1925 by the Panamint Mining Company.

Idle.

Bibliography: State Mineralogist's Report XVII, pp. 280-281; XXII, pp. 495 and 500.

GOLD.

Anthony Mine (See Gold Bug Mine).

Burro, New Discovery and Gem Mines. This property, comprising 5 claims, is situated in Jail Canyon, 14 miles north of Ballarat and 3 miles up the canyon from the road in Panamint Valley. Elevation 3700′. Owner, R. D. Warnock, Trona, California. Under lease to *Panyo Gold Mining Company;* W. A. Watts, president, 427 McCadden Place, Los Angeles; R. A. Norton, manager, 613 North Beverly Drive, Beverly Hills, California.

The old Burro Mine, also known as the *Protection Group,* has had no work done on it for many years. A series of parallel quartz veins with a NW.-SE. trend here occur in the schist. They vary in width from 2′ to 10′. Development consists of a shaft 116′ deep and a tunnel 200′ long, also a number of short tunnels and shallow shafts on different veins. These veins are reported to carry from $2.50 to $25 per ton in gold.

The New Discovery and Gem Mines are about 1500′ west of the Burro Mine. This property differs from others of the district, both in the enclosing wall rock and the character of the ore.

The veins occur in a granitic laccolith whose outcrop has a width of about 1200′ to 1500′ and which is exposed on the sides of the mountains for a distance of several miles, largely to the south of Jail Canyon. This mass appears to have been intruded into the schists, limestones and quartzites of the Panamint Mountains. The veins are parallel to the foliations of the sheared granite near its eastern contact with the schist. There is evidence of some faulting and rotation of the veins in the canyon. The displacement, if any, is small. Strike of veins on the north side of the canyon is N. 25° E., while on the south side it is west of north. The dip is about 65° W. Two veins have been encountered in the workings, only one of which has been developed. The principal vein varies in width from 2′ to 12′ and in the ore shoot, as now exposed, shows an average width of about 8′. The vein filling is quartz and some fragments of wall rock cemented with quartz. The vein has been oxidized to a depth of about 50′ to which point some free gold is found. Below this depth the mineralization consists of iron sulphides, pyrrhotite, pyrite and probably marcasite, a little chalcopyrite and bornite, galena and zinc blende. The gold is associated with these sulphide minerals. The vein appears to be free from each wall, the footwall being especially well defined.

On the south side of the canyon there are some short tunnels, evidently driven years ago in search of lenses of oxidized ore. Principal development is on the north side of the canyon. A tunnel has been driven north 260′ near the bottom of the canyon. At 120′ from the portal of this tunnel there is a stope 50′ long by 3′ wide. This stope was holed through to the surface, a distance of about 50′. In this tunnel the vein varies from a few inches to 3′ in width. The vein matter is oxidized and shows very little quartz. Some 40′ west of the portal and at the same elevation is the collar of a vertical shaft 135′ deep. This shaft is reported to have cut a vein at a depth of 55′. This must be a different vein from the one in the tunnel although it could not be seen due to lagging in the shaft. On the 75′ level a crosscut east intersected the vein at 20′ from the shaft. A drift was driven north 35′. To the south, an old stope cave has filled the drift, 25′ south of the crosscut. This stope begins at the crosscut, is about 20′ long and from 2′ to 5′ wide. The vein filling is quartz which in places shows a ribbon structure. Some 15′ north of the shaft the vein is split by a horse of country rock. In the face it is narrow but looks like ore. It is probable that it would open into another shoot or lens if followed to the north. This appears even more probable in view of the fact that the shoot stoped in the tunnel above would still be to the north of this drift if it comes down to that depth.

On the 125′ level a crosscut east intersected the vein 10′ from the shaft. A drift has been driven south about 150′. The crosscut struck the vein in the ore shoot but no drifting has been done to the north. To the south the shoot shows about 45′ long and from 8′ to 12′ wide. On this level it is reported to average $16 to $20 per ton in gold, with some 2′ near the center of the vein which runs much higher. The high-grade ore appears to occur as massive iron sulphide bands. Where exposed these bands have been oxidized on the surface to limonite but if a piece is broken open it is found to consist entirely of the unaltered sulphides. On these oxidized faces may be seen occasional specks of

cuprite. At 25′ south of the crosscut there is a 38′ winze, full of water. The vein is reported to show full width of the winze, without having both walls. Some 35′ or 40′ south of the south end of the ore shoot the vein has been lost in the drift. Whether it has been faulted or the drift has simply passed into one wall has not been determined.

Water is obtainable in the canyon where a stream of some 200 gallons per minute is flowing. A camp of three buildings (accommodations for about 6 or 8 men) has been established about one-fourth of a mile down the canyon from the mine.

Equipment at the mine consists of blacksmith shop; 6-h.p. LeRoi gas engine hoist; jackhead pump, 30 g.p.m., driven by 6-h.p. gas engine.

The mine makes about 3500 gallons of water per day. Idle at present but operators expect to shortly erect a small flotation mill for treatment of the ores.

Bibliography: State Mineralogist's Reports XV, pp. 81–82; XXII, pp. 470–471.

Cecil R. Mine is 4 miles south of Ballarat and one mile east of the main road in Panamint Valley. It comprises one claim. Elevation 1250′. Owners, Edward Hague, Long Beach, and M. J. Sherlock, Box 82, Trona, California. Under lease to Mrs. Luella O'Keefe, 3070 West 12 Street, Los Angeles.

Here occur several parallel veins separated by a few feet of the schist country rock. The strike is north-south, dip 20°–30° west. The principal vein is from 3′ to 8′ wide, with an average width of about 5′. A few feet in the footwall of this vein are two other narrow veins. They vary in width from a mere seam to about 12″. All of these veins conform to the schistosity of the wall rock and they follow the contortions of the schist which is intensely folded.

Principal development has been done on the narrow, footwall veins. A shipment of two tons of selected ore was made during the current year which is reported to have yielded $250 per ton in gold. On the south side of the canyon there is a 200′ tunnel with several short raises, evidently put up in search of high-grade pockets. Much of the old working has been shut off by pack walls of waste rock. This fill is everywhere in evidence, indicating that all of the ore taken from the mine has been selected.

Some 50′ below these workings are two tunnels on opposite sides of the canyon, each about 150′ long. These have been driven on the wide vein. In the tunnel to the south there is exposed a quartz lens 130′ long and 3′ to 8′ wide. Present lessee reports values in this lens of $10 per ton.

There are 2 men working on a high-grade streak in the upper tunnels.

Curran Mine.[8] "The Curran Mine, property of Mrs. H. H. Thompson, Ballarat, California, is situated about half a mile northeast of Panamint town site. * * *

"There are several quartz veins on the property. The principal one strikes roughly N. 40° W. and dips 25° NE., apparently following the schistosity of the schist. The average width of the vein is 2′.

[8] Murphy, F. M., *op. cit.*

It is developed by approximately 300′ of workings. The country rock is the Surprise formation. The ore has not been successfully concentrated due to the high sulphide content, but according to Robert Warnock, it ranges in tenor from $13 to $17 per ton in gold.

"The character of the ore is entirely different from that of the surrounding mines. The vein is heavily mineralized and the typical ore is composed almost wholly of pyrrhotite, pyrite and marcasite with subordinate coarsely granular, glassy quartz. Pyrrhotite and pyrite impregnate the wall rock for a distance of several inches from the vein. Examination of several specimens of massive pyrrhotite ore in reflected light showed the development of marcasite closely associated with siderite. The marcasite possesses the usual characteristic properties ascribed to this mineral and almost invariably shows concentric rings; but its identity was fixed by the rotation of the plane of polarization of reflected light. The carbonate was identified under the petrographic microscope. It has a high index of refraction and an ashen-gray color with distinct absorption, which, according to Winchell is especially characteristic, although not pronounced. The chemical properties also closely conform to those of siderite.

"Siderite appears to be both contemporaneous with and later than marcasite. Though it is often concentric with the structure of the marcasite and fills the spaces between successive rings, yet it frequently forms veinlets which cut across the marcasite. Veinlets of siderite, associated with a few widely scattered grains of quartz, are commonly bordered by colloform marcasite. * * * Again marcasite replaces pyrrhotite along apparent cleavage or crystallographic directions which expand into more or less globular shaped masses built up of concentric shells.

"Chalcopyrite is commonly associated with the siderite veinlets and was probably contemporaneous with and earlier than siderite. Occasionally veinlets of siderite, of such dimensions as to be noticed only under high magnification, cut entirely through grains of chalcopyrite. Chalcopyrite cuts across the structure of the marcasite, which fact suggests but does not prove replacement. * * *

"Pyrite is replaced by an intricate network of quartz veinlets. However, it is to be regretted that the relations of pyrite to the other minerals in the deposit could not be ascertained with certainty. Gold was not observed in polished sections of the ore. On the assumption that there has been a single generation of quartz, the order of deposition appears to be as follows: pyrite, quartz, pyrrhotite, chalcopyrite, marcasite, and siderite overlapping with the marcasite and chalcopyrite.

"The occurrence of marcasite replacing pyrrhotite and the development of a carbonate, particularly a sideritic carbonate, both contemporaneous with and later than marcasite, has been recently mentioned by several observers. The facts seem to indicate that the marcasite may have either a supergene or hypogene origin. * * * The assigning of a hypogene origin for the marcasite was based largely on the fact that quartz was deposited later than marcasite and that supergene sulphide deposition is only rarely accompanied by quartz.

"Oxidation products are almost entirely lacking in the ores from the Curran Mine. The sulphides occur at the surface and pyrrhotite

has not been noticeably oxidized to limonite. In the silver-bearing veins previously described, the zone of oxidation is shallow and commonly the sulphides occur at the surface. Moreover, there is little indication of supergene enrichment in the silver ores of the district. In the massive sulphide ore from the Curran Mine there is certainly no reason for assuming a supergene origin for the chalcopyrite. It seems improbable, therefore, that marcasite was deposited by supergene solutions, and a hypogene origin is favored.''

Gold Bug Mine (formerly known as *Anthony Mine* and originally the *Post Office Springs Mine*), comprising 5 unpatented mining claims, is on the south side of Pleasant Canyon, 2 miles west of the Radcliff mill and about 4 miles east of Ballarat. Elevation at the mine 4200′. Owner, Mrs. Ada Norris, Box 443, Trona, California.

This property was first located in 1893 by C. Anthony. In 1895 or thereabouts a 5-stamp mill was erected in Pleasant Canyon and a few hundred tons of ore milled. No record of production is available.

The sides of Pleasant Canyon are very steep and rugged. On this property the south side rises some 1100′ above the bottom of the canyon, the top 300′ or 400′ being a sheer cliff. The rocks exposed in the first 600′ to 700′ above the bed of the canyon are schists which have been intensively folded. Resting on these schists is from 400′ to 500′ of limestone also folded and faulted. This is brown, crystalline limestone and where traversed by the veins on this property its strike is N. 10° W., dip about 40° E. An interlacing vein system occurs, the principal vein having a N. 10° W. strike, with a dip of 40° to 45° W. Another series, having approximately the same strike but with an easterly dip, intersects the main vein as exposed in the face of the cliff. A third series of subordinate fractures strike NW.-SE., with a steep southeasterly dip, forms junctions with the main vein from the footwall side but do not cross the vein into the hanging wall. The ore has formed along the intersections and where the footwall stringers are most numerous. The main vein has been traced for a distance of about one-half mile south from the face of the cliff which marks its northern terminus. The vein varies from a few inches to about 3½′ in width. Mineralization consists of lead carbonate, iron oxide, occasional pyrite and free gold, which is frequently visible. A rather faint copper sulphate stain may be seen in most of the ore. The highest grade ore is in the bands of hematite and the white to iron-stained porous quartz which is frozen to the hematite.

Development on the north end consists of a number of short tunnels and two small stopes.

Just south of the face of the cliff an underhand stope has been mined from the surface. This stope is about 50′ long, 3½′ wide and some 20′ deep. In the north end there is exposed about 18″ of ore which is reported to assay about $60 per ton. Approximately 100′ below this stope, a tunnel in the face of the cliff has been driven south 100′ on the vein. A stope 40′ long, about 30′ high and 2′ to 2½′ wide was worked from this tunnel.

On the south end the Gold Bug No. 1 Claim has been leased to Joseph Klein, 120 North Main Street, Los Angeles. This property is about 2500′ south of the above-described workings. The development here consists of some short tunnels and 40′ inclined shaft. On the 20′

level there is a drift 30′ N. and the same distance south. Below the south drift there is a stope 20′ long by 2½′ wide. The bottom of this stope is tapped by a raise from the bottom of the shaft. The ore 16″ to 20″ wide is reported to carry $40 per ton.

A two-rope, gravity, aerial tram, 1800′ in length, connects the mine workings with the bottom of the canyon where the owner plans the immediate erection of a small mill. Water will be obtained from a strong spring about 2000′ down the canyon. It will be pumped to the mill site against a 250′ head.

Gold Hill Mine, comprising 4 patented claims is on the east slope of the Panamint Mountains, some twelve miles south of Bennett's Well and just east of Butte Valley. Elevation 5400′. Owners, Fred W. Gray, 3503 McClintock Avenue, Los Angeles, and Wm. Hyder, Trona, California. Property is under lease to Miss Louise Grantham, Los Angeles.

According to the present owners this property was patented in 1894, reverted to the state and was bought by them at a tax sale in 1919.

This property was not visited, the following information having been obtained from the owners.

The vein which is traceable for about 2000′, occurs in dolomite. It is lenticular. The lenses are up to 60′ in length and 25′ in width. Mineralization consists of lead carbonates and galena, with gold and silver as associate minerals.

Development consists of three tunnels, the longest of which is 300′.

It is reported that the lessee intends to build a mill at Warm Springs which is about 6 miles from the mine.

Gold Tooth Mine, comprising 2 claims, is on the west slope of the Panamint Range, 10 miles south of Ballarat. Elevation at mine 1400′. Owners, A. R. Greenslitt, R. E. Baughman, Trona, California, and John M. Garver, 6329 Rita Street, Huntington Park, California. Under lease to Joe Horn, 628 West Fairmont Street, Glendale, California.

This property was worked about 25 years ago at which time it was known as the *Schuellheist Mine.*

The formations here exposed consist of quartzite, quartzite schist, thin acidic to dioritic dikes and a brown, highly-altered porphyritic rock which was not identified. A strong vein traverses these rocks, strike about N. 10° W., dip 70° E. In places it is accompanied on the hanging wall by a narrow diorite dike. In general; however, the hanging wall is quartzite or quartzite schist, while the footwall is the altered porphyry or a schist. In various openings on the property the vein shows a width of 8′ to 10′. The vein matter is composed of silicified, schistose igneous dike rock and quartz which is the cementing material. Gold, the only valuable mineral contained in the ore, occurs free and associated with iron sulphides, which are not abundant at depths reached in the present workings.

Development on the north end of the property consists of a 50′ crosscut tunnel from which a drift north has been driven 100′, at which point a hole was made through the wall to the surface. At this point the vein is some 10′ wide, 4′ of which is reported to carry about $16 per ton in gold.

About 1000′ south of these workings is an old tunnel. It was driven north on the vein a distance of about 150′. A stope was worked up to the surface a distance of about 75′. Here the vein has a width of from 6′ to 10′ but records of its production are not available.

An aerial tramway 500′ in length is being constructed from the mine to a 5-stamp mill about 300′ below the mine. A Tracy concentrating table will be installed after the stamps. It is not the present plan to use plates. Water will be obtained from a well in the valley some 2000′ west of the mill. Water will have to be raised about 150′.

Five men are working on the erection of the tramway.

Holy Roller Prospect is in the South Park District. Ore said to average $4.90 per ton occurs in a flat deposit, 25′ wide, in the limestone near a schist contact.

Bibliography: State Mineralogist's Report XV, p. 79.

Horn Spoon Mine.[9] "The Horn Spoon Mine, property of Christopher Wicht, is situated near the head of Hall Canyon. The elevation of the mine is 7500′. The country rock is conglomerate schist. The property is developed by three tunnels, one of which has been run on a fault fissure which dips 35° SE. The vein has been faulted and was not encountered in the other two tunnels. * * * The vein is about 2′ wide and is reported to average $35 per ton in gold. It has been considerably crushed and has a gouge seam on the footwall. The ore is a highly-oxidized breccia consisting of fragments of generally dark-colored quartz cemented by crusts of secondary quartz. Rather coarse-textured gold is the only ore mineral present in the deposit and occurs embedded in masses of limonite.

"There are several massive quartz veins on the property but they are in general quite barren."

Mountain Girl Mine (from notes by F. M. Murphy). It is situated in the head of Happy Canyon, about 4 miles south of the town of Panamint. It includes 2 mining claims, the Mountain Girl and Mountain Girl Fraction. "The original locator and present owner is Harry C. Porter, Trona, California. The mine is at an elevation of about 8000.′ * * * The owner has realized fair returns selling specimens of coarse gold. The mine is developed by several tunnels, a shaft, and many opencuts and trenches.

"There are a number of small quartz veins on the property. The contact between them and the walls is sharp. Rarely these veins follow the joining of the conglomerate schist, country rock." Post-mineral faults of small displacement offset the veins in many places. The veinlets carrying coarse gold are rarely over 5″ in width and generally average from 2″ to 3″. "According to the owner the wider veins are usually barren. They strike from N. 35° E. to N. 50° E. and apparently are branches of a main vein which strikes N. 25° E. and dips 50° E. The latter is probably a lens and is traceable but a short distance on the surface. The maximum width of the lens is over 30′ and averages $9 per ton in gold.

"A characteristic feature of the deposit is the occurrence of coarse gold at the junction of calcite stringers with quartz veins. These

[9] Murphy, F. M., *op. cit.*

stringers are rarely over a hairbreadth in thickness but may attain a width of $\frac{1}{16}''$. Usually, they join the vein at an acute angle and apparently are confined to the footwall side. * * * The general occurrence of coarse gold at the junction of calcite stringers with quartz veins was noted and this suggests a dependent relationship.

"The quartz of the lens is very similar in character to that in the Panamint district, being massive, milk-white, and coarsely crystalline; while quartz of the gold-bearing veinlets is more glassy. Siderite is another nonmetallic mineral of the deposit.

"The metallic minerals of hypogene origin include, in the approximate order of their abundance, pyrrhotite, arsenopyrite, chalcopyrite, pyrite, and gold. Commonly pyrrhotite has been metasomatically developed in the wall rocks adjacent to the veins and always as a replacement, either in whole or in part, of quartzite fragments of the country rock."

New Discovery Mine. (See Burro Mine.)

O. B. Joyful Mine. (See Panamint Mines Co.)

Panamint Mines Company, Eugene Kelley, vice president and secretary, Bankers Building, Los Angeles, has under lease the O. B. Joyful or *Tyler Mine* with which is consolidated the *Aster* and *Thurman* mines. The above company has subleased this property to Neil O'Donnel, 4029 West 21 Street, Los Angeles. It consists of 14 claims, held by location in the south branch of Tuber Canyon on the west slope of the Panamint Mountains, some 15 miles north of Ballarat. Elevation at principal mine workings 3450′. Owners, C. W. Tyler, Trona, California, and C. H. Tyler, Morro Bay, San Luis Obispo County, California.

The O. B. Joyful or Tyler property was located about 1893 by Robert Montgomery and associates. Most of the development work was done by J. P. Flint between 1898 and 1912. The property has been worked intermittently since 1898, with a reported production of from $200,000 to $300,000.

The country rock, consisting largely of diorite and schist, has been subjected to much faulting. Two major fault systems are apparent: one having a N. 45° E. strike and dipping 30° to the SE., the other strikes N. 40° W. and dips 45° NE. According to Clarence R. King,[10] the first is an overthrust of large displacement, while the other is a normal fault system of small displacement. Barren quartz veins were first formed, usually close to the contact of diorite and schist. Later movements crushed the quartz and opened channels for the mineralizing solutions. In many places where the veins are wide the crushing of the quartz was confined to the portions adjacent to the wall rock. Galena, pyrite, gold and silver minerals together with a second generation of quartz were deposited either in the crushed quartz veins or in the wall. Two types of ore resulted (1) a loose, friable vein-filling of crushed quartz, very white; (2) mineralization of the crushed schist wall-rock, the vein quartz being barren. The ores of the Tyler Mine belong to the first class, while the Aster Mine ore is representative of the second. The metallic minerals in the first are gold and cerussite;

[10] Report by Clarence R. King, Clarkdale, Arizona, for Eugene Kelly, dated May 2, 1932.

in the second, gold, cerussite and primary sulphides. Nodules of metallic sulphides have been found in the Aster Mine assaying from 8.20 to 9.75 ounces of gold per ton. Encrustations of gypsum are everywhere visible in both veins. Generally the Tyler vein has a diorite footwall and hornblende schist hanging wall. The ore in the Tyler Mine consists of lenticular bodies of quartz from one to 30′ wide, separated by pinches in the vein or the lenses may overlap, with narrow layers of schist between. Intermittent outcrops of veins may be found between the Tyler and Aster workings, a distance of some 2000′.

The Aster vein shows a series of overlapping quartz lenses from 5′ to 30′ wide. The Aster vein quartz is not so badly crushed with the result that the values are largely in the crushed schist wall-rock usually on the hanging wall side.

Principal development work has been done on the Tyler Mine. The main tunnel which corresponds to the fourth level was driven S. 60° E., 900′. At 800′ from the portal there was encountered a fault, strike about N. 20° W., dip 20° SW. Another major fault, known as the 'cut-off' fault is found on the surface about 150′ to 200′ east of the line of the main tunnel. Its strike is northwest with a dip of 45° SE. The vein was not found in the main tunnel, the supposition being that it has been displaced by one or both of these faults. At some 200′ from the face of the main tunnel a drift was driven west about 100′. Here a raise was put up which encountered the vein about 20′ above the tunnel level. From this point to the surface, a vertical distance of about 200′, the vein is intact.

On the level 80′ above the tunnel level, the vein has been followed for a distance of 400′, with much stoping. One stope above this level is 90′ long, 100′ high and averages 22′ in width. The ore from this lens is reported to have yielded $12 per ton in the mill. Two shafts known as the North Shaft and the South Shaft have been sunk to this level. They are about 200′ apart.

Mr. King estimates the present ore reserves of the Tyler Mine as follows:

Hanging wall shoot only; width 4′; value $21.32 per ton; 750 tons.

Full width of vein 15′; value $4.50 per ton; 15,000 tons.

Development at the Aster Mine consists of a series of opencuts, a 60′ shaft and a 100′ tunnel, driven in an easterly direction under the opencuts. The vein here varies from a mere seam to 20′ in width. It is highly colored by the oxides of iron and manganese.

Eight tons of selected ore were shipped from these opencuts in July, 1932.

Returns were $135 net, per ton. The ore carried 9½% lead and 10 ounces of silver, the remainder of the values being in gold.

Formerly the ore from the Tyler Mine was milled in two 3-stamp batteries; two 6′ by 16′ amalgamating plates. Tailings were stacked just below the mill and trammed to three 24′ cyanide tanks. This plant in fair condition remains on the property.

Equipment includes at the Aster Mine, 8 by 8 portable Ingersoll-Rand air compressor and 400′ aerial tramway.

Four men working driving tunnel on the Aster group.

Bibliography: State Mineralogist's Reports XV, p. 74; XXII, p. 465.

Radcliff Mine, consisting of 10 patented claims and a mill site, is situated on the south side of Pleasant Canyon, on the west slope of the Panamint Mountains, about 6 miles east of Ballarat. Elevations on the property range from 4900′ to 7000′. Owner, W. D. Clair, 208 South Union Avenue, Los Angeles.

The property is accessible by road from Ballarat. It comprises the following patented claims: Sun Rise, Grover Cleveland, John G. Carlisle, Kentucky, Texas, Joker, Joker Extension, Never Give Up, Treasure Vault and W. G. Quartz; also the Cleveland mill site claim. These were located about 1897 by Messrs. Radcliff and Halbert. Early operations extended over a period of some five years, about 1898–1903. During this time approximately 15,000 tons of ore were mined. Various estimates as to the values recovered from this ore have been made. It seems probable that the production has been about $300,000.

The following information is taken from a report on the property by F. C. Garbutt, dated September 15, 1902, and from notes by F. M. Murphy, also information furnished by the owners.

The country rock, according to Murphy, may be variously described as a quartz-sericite gneiss, metaquartzite or conglomerate schist, with interstratified beds of limestone. While there are several veins on the property, production has been largely from one principal vein which occurs at or near the contact of the schist with the gneiss. Its strike is NW.-SE. and it dips 50° SW. The footwall is gneiss and schist forms the hanging wall. It varies in width from 4′ to 55′. The vein filling is a coarse, glassy variety of quartz and often has a smoky, greasy aspect. Microscopically, Murphy found that the quartz has been greatly strained and crushed. The ore minerals in the veins are pyrrhotite, pyrite, gold and probably chalcopyrite. Both oxidized and sulphide ores have been mined.

"Pyrrhotite is the principal sulphide and is always massive. It replaces quartz and pyrite. Pyrrhotite surrounds grains of pyrite and often fills cracks and seams in them and there is, therefore, no doubt that the pyrite is older and has been replaced. Pyrite is much less abundant than pyrrhotite and was only observed after specimens of the ore had been polished. Typical sulphide ore is composed largely of pyrrhotite and quartz. The gold fills minute fractures in pyrrhotite or in the quartz and is rather coarse-textured." Some oxidation is apparent to present depths below the outcrop (about 500′) but is most noticeable to a depth of about 200′.

The ore shoots are usually found on or near the footwall. The principal shoot showed a thickness of from 20′ to more than 50′ and had a length along the strike of approximately 125′. Its downward extension has never been proved. According to Garbutt all workings below the second level have been made entirely in the schistose formation and away from the footwall. He also mentions a large vein of sulphide ore which was cut in various places below the second level. Samples cut by him in this vein, ranging from 4′ to 10′ in width varied in value from $14 to $64 per ton. A third shoot of ore is indicated to the east of the larger opencut.

Development consists of five adit levels driven approximately 100′ vertically, apart, the lower one being about 500′ below the outcrop. The total underground workings (see map) aggregate about 2500′. The

FIG. 3. Radcliff Mine and mill showing 7800-foot aerial tram to mill.

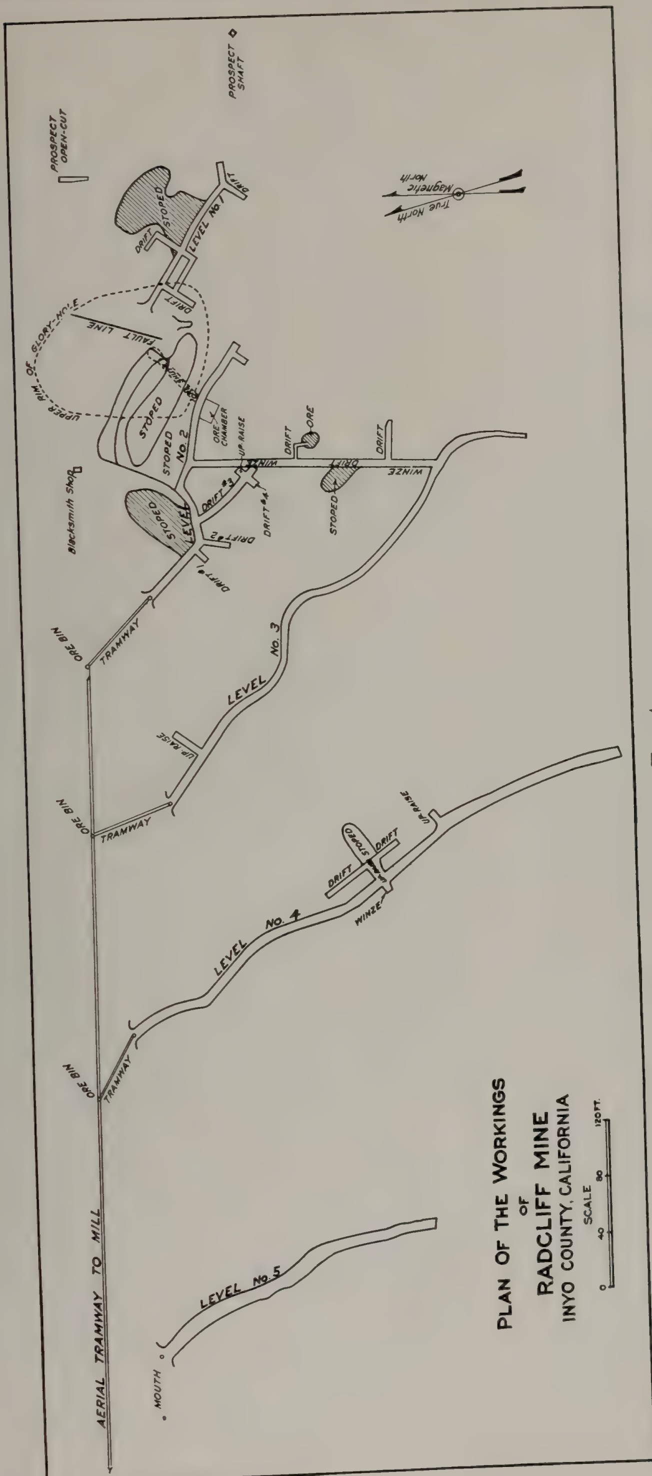

PLAN OF THE WORKINGS
OF
RADCLIFF MINE
INYO COUNTY, CALIFORNIA
SCALE
0 40 80 120 FT.
AERIAL TRAMWAY TO MILL
MOUTH
LEVEL No. 5
LEVEL No. 4
LEVEL No. 3
LEVEL No. 2
LEVEL No. 1
ORE BIN
TRAMWAY
UP RAISE
WINZE
DRIFT
STOPED
ORE
ORE CHAMBER
DRIFT #1
DRIFT #2
DRIFT #3
DRIFT #4
Blacksmith Shop
FAULT LINE
UPPER RIM OF GLORY-HOLE
PROSPECT OPEN-CUT
PROSPECT SHAFT
True North
Magnetic North

FIG. 4.

principal production of ore to date has come from a glory hole. This opencut is 90′ long, 55′ wide and 45′ in height. The average value of the ore taken out here has been estimated at from $18 to $20 per ton. Some small stopes have been worked from the third and fourth levels. Reports by various engineers all indicate the probabilities of developing a considerable tonnage of ore with a very small amount of work, consisting principally of crosscuts to the footwall from existing drifts. These conclusions have, in part, been proved by the owners, who state that every time they crosscut to the footwall in the ore zone they encounter ore, the average value of which is from $15 to $18 a ton. Some 4000′ north of these workings a 40′ shaft has been sunk on an 18″ cross vein which is reported to be high grade.

The property is equipped with a 20-stamp mill. The present owners have treated some 15,000 tons of the tailings from which they have recovered $4.25 a ton. There now remains to be treated about 5000 tons. Their plant consists of a 4 by 6 Marcy-type mill, Dorr duplex classifier, 3 agitators and 5 zinc boxes, capacity about 30 tons a day. They are now increasing the milling capacity to 50 tons daily. The future ore for this mill will come from stopes on the first, second and fourth levels. It is believed that the average value of the ore will be about $15 to $17 a ton.

Six men are employed on mill construction.

World Beater Mine (now known as the *Pleasant Canyon Group*), consists of 5 claims in Pleasant Canyon, approximately 1000′ northeast of the Radcliff workings. Owner, *Ballarat Mining Corporation,* Mrs. M. A. Thompson, secretary, 8351 Blackburn Avenue, Los Angeles.

The property was discovered about 1896 and worked intermittently until 1908. It is reported to have produced some $250,000 from a good grade of ore. No authentic figures are available.

It is reported that the vein, occurring between diorite and schist walls, has a NE-SW strike and dips to the southeast; that it is from 2′ to 12′ in width and the ore shoot mined was 70′ to 80′.

Developed by three crosscut tunnels, the lower one of which is about 370′ below the outcrop. Several hundred feet of drifting was done in these tunnels and some shallow winzes sunk from the lower tunnel.

Equipment includes a 10-stamp mill and cyanide plant, although the latter was not put into operation until near the close of the mine's activity.

In recent years only assessment work has been done.

OIL FIELD DEVELOPMENT OPERATIONS

R. D. BUSH, State Oil and Gas Supervisor

From April 3, 1932, to and including July 2, 1932, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
FRESNO COUNTY:					
Kettleman North Dome Asso.	32	21	17	32	Kettleman North Dome
Standard Oil Co.	19	21	17	67	Kettleman North Dome
Union Oil Co.	29	21	17	King 2	Kettleman North Dome
KERN COUNTY:					
Belridge Oil Co.	27	27	20	51-27	Belridge
Belridge Oil Co.	35	27	20	27-35	Belridge
Milham Exploration Co.	7	28	23	S. P. 32-7	Buttonwillow Gas
Milham Exploration Co.	7	28	23	S. P. 41-7	Buttonwillow Gas
Milham Exploration Co.	7	28	23	S. P. 43-7	Buttonwillow Gas
Milham Exploration Co.	9	28	23	S. P. 14-9	Buttonwillow Gas
Charles B. Gauthier	24	25	18	1	Devils Den
General Petroleum Corp.	22	29	27	Hensley 1	Fruitvale
Mohawk Petroleum Co.	21	29	27	10	Fruitvale
Petrol Producing Corp.	21	29	27	Bloemer 1	Fruitvale
Tarr & McComb Oil Co., Ltd.	23	29	27	1	Fruitvale
Western Gulf Oil Co.	21	29	27	Bittle 1	Fruitvale
Western Gulf Oil Co.	21	29	27	Harty 1	Fruitvale
Western Gulf Oil Co.	22	29	27	12-KCL-B	Fruitvale
Western Gulf Oil Co.	22	29	27	Price & Stewart 2	Fruitvale
Western States Petroleum Co.	21	29	27	Unruh 1	Fruitvale
R. Whiston	23	29	27	Whiston 1	Fruitvale
C. C. M. O. Co.	23	28	27	41	Kern River
Welport Oil Co.	22	29	21	1	McKittrick
Welport Oil Co.	26	29	21	10	McKittrick
Welport Oil Co.	26	29	21	105	McKittrick
Miocene-Sunset Oil Co.	23	32	23	3-A	Midway
Fred D. Turner	22	32	23	Turner 1	Midway
Fred D. Turner, Trustee	22	32	23	Bull 2	Midway
Fred D. Turner, Trustee	22	32	23	Bull 3	Midway
Emerich Oil Corp., Ltd.	19	27	28	1	Mt. Poso
Gulf Verde Oil Co.	19	27	28	4	Mt. Poso
Modoc Petroleum, Ltd.	28	26	28	Vedder 1	Mt. Poso
Pongratz Oil Co.	10	27	28	Pongratz-Tavis 1	Mt. Poso
California Western Oil Co., Ltd.	7	28	29	8	Round Mountain
C. C. M. O. Co.	1	28	28	Coffee 1	Round Mountain
Welport Oil Co.	19	29	21	2	Temblor
Welport Oil Co.	19	29	21	4	Temblor
Welport Oil Co.	29	29	21	1	Temblor
Delano Oil Co.	2	25	26	1	
Rio Grande Oil Co.	7	27	19	Utting 1	
KINGS COUNTY:					
Universal Consolidated Oil Co.	25	23	18	Bunting 1	Kettleman Middle Dome
W. M. Evans and Mabel L. Evans	32	22	18	1	Kettleman North Dome
Dudley Dome Oil and Gas Co., Ltd.	9	23	20	1	
Kettleman Reef Ridge Oil Co.	10	23	16	2	
Glenn Woodward	32	22	20	1	
LOS ANGELES COUNTY:					
Shell Oil Co.	33	3	13	Reyes 43	Dominguez
Pacific Western Oil Co.	8	2	14	Rubel 16	Inglewood
Standard Oil Co.	17	2	14	L. A. Investment 1, 69	Inglewood
Beach Petroleum Corp., Ltd.	19	4	12	Harlow 2	Long Beach
R. R. Bush Oil Co.	19	4	12	Barnes 4	Long Beach

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
L. A. COUNTY—Continued					
R. R. Bush Oil Co.	19	4	12	Brennecke 3	Long Beach
Dabney-Johnston Oil Corp.	13	4	13	85	Long Beach
Ora Negra Development Corp.	14	3	16	1	Newhall
Southern California Drilling Co.	12	3	16	Needham 2. 1	Newhall
Spencer & Brubaker	8	3	16	1-A	Newhall
Superba Petroleum Corp.	11	3	16	1	Newhall
Wilshire Annex Oil Co.	34	2	14	3	Potrero
J. J. Stephens	19	3	13	Stephens-Rosecrans 1	Rosecrans
Continental Oil Co.	3	5	12	Bixby 34	Seal Beach
F. G. Balridge	29	2	12	Glasscock & Woods 1	
F. G. Balridge	29	2	12	Wm. Specht 1	
F. G. Balridge	31	2	12	Joe Espittalier 1	
ORANGE COUNTY:					
Standard Oil Co.	18	3	10	Murphy-Coyote 111	Coyote Hills
Standard Oil Co.	18	3	10	Murphy-Coyote 112	Coyote Hills
John E. Hill	10	6	11	Hill 1	Huntington Beach
Ben F. Mun	34	5	11	H. B. Fee 14	Huntington Beach
Ben F. Mun	34	5	11	H. B. Fee 16	Huntington Beach
S. S. Wold	35	5	11	5	Huntington Beach
RIVERSIDE COUNTY:					
Indio Hills Exploration Co., Ltd.	35	3	5	1	
SAN BENITO COUNTY:					
Russell D. Freed	25	13	5	1	
SAN LUIS OBISPO COUNTY:					
J. D. Martin	5	32	13	2	Arroyo Grande
Emerich Oil Corp., Ltd.	22	32	22	1	
SANTA BARBARA COUNTY:					
Barnsdall Oil Co.	16	4	29	88-8	Elwood
Bolsa Chica Oil Corp.	25	4	29	191-3	Elwood
Pacific Western Oil Co.	16	4	29	92-9	Elwood
Caroline C. Spalding	16	4	29	Blue Goose 93 6	Elwood
O. C. Field Gasoline Corp.	6	7	33	McLean 1	Lompoc
La Mesa Oil Exploration Co.	28	4	27	Ross 1	Mesa
Peter Sorensen	28	4	27	Sorensen 1	Mesa
B. L. Webb	28	4	27	1	Mesa
B. L. Webb	28	4	27	2	Mesa
M. H Casey	11	8	31	1	
Charles F. Simonds	9	4	28	1	
Standard Oil Co.	Santa	Rosa	Island	Santa Rosa 1	
The Texas Co.	33	4	25	Carpinteria Com. Lease No. 3, 1	
SANTA CLARA COUNTY:					
C. H. Shaw	1	12	3	Shaw 4	Sargent
TEHAMA COUNTY:					
Valley Petroleum Asso.	27	25	4	1	
TULARE COUNTY:					
Gravity Exploration Co.	35	22	23	Hudson-Buck-Jennings 4	
Gravity Exploration Co.	2	23	23	Hudson-Buck-Jennings 5	
Gravity Exploration Co.	11	24	23	Hudson-Buck-Jennings 2	
Gravity Exploration Co.	12	24	23	Hudson-Buck-Jennings 3	
R. H. Ingraham	24	22	27	1	
Sheldon & Gholson	34	22	27	1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
VENTURA COUNTY:					
Wilshire Annex Oil Co.	20	4	21	1	Ojai
The Woodrow Petroleum Corp., Ltd.	4	3	24	Woodrow 1	Rincon
Edward M. Lesperance	31	4	20	Boosey 1	Santa Paula
Superior Oil Co.	13	4	21	West 3	Santa Paula
Harmon and Deal	33	5	19	2	Sespe
H. A. Ivers	1	4	20	Star 7	Sespe
H. C. Turnham	6	2	17	3	Simi
Associated Oil Co.	27	3	23	Lloyd 130	Ventura
H. C. Turnham	7	2	17	1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

From July 3, 1932, to and including October 1, 1932, the following new wells were reported as ready to drill:

Company	Sec.	Twp.	Range	Well No.	Field
FRESNO COUNTY:					
Kettleman North Dome Assoc.	30	21	17	87	Kettleman North Dome
Standard Oil Co.	29	21	17	41	Kettleman North Dome
Standard Oil Co.	29	21	17	58	Kettleman North Dome
KERN COUNTY:					
H. J. Bardwell	14	28	20	1	Belridge
Continental Oil Co.	36	27	20	Result 3	Belridge
General Petroleum Corp.	6	28	23	Morris 2	Buttonwillow Gas
Milham Exploration Co.	17	28	23	S. P. 21-17	Buttonwillow Gas
Milham Exploration Co.	17	28	23	S. P. 41-17	Buttonwillow Gas
A. S. Holloway	11	25	18	Miller-Bump 1	Devils Den
Cascade Oil Co.	23	29	27	Hasson 1	Fruitvale
G. de Bretteville	21	29	27	2	Fruitvale
Emerich Oil Corp., Ltd.	23	29	27	Greeley 1	Fruitvale
N. P. Gerard	23	29	27	1	Fruitvale
Harrison Oil Syndicate	23	29	27	1	Fruitvale
Kern Petroleum Corp.	21	29	27	Davis 1	Fruitvale
Mohawk Petroleum Co.	21	29	27	11	Fruitvale
Mohawk Petroleum Co.	23	29	27	12	Fruitvale
Treasure Drilling Co., Ltd.	23	29	27	Treasure 2	Fruitvale
Western Gulf Oil Co.	21	29	27	Bittle 2	Fruitvale
Western Gulf Oil Co.	21	29	27	Schmidt-Com. 1	Fruitvale
Western Gulf Oil Co.	22	29	27	Price & Stewart 3	Fruitvale
Agey Petroleum Co.	28	27	27	Agey 2	Kern River
Modoc Petroleum, Ltd.	28	26	28	Vedder 2	Mt. Poso
H. L. Woodward	28	26	28	Vedder 1	Mt. Poso
Hay Petroleum Corp., Ltd.	22	30	29	1	
KINGS COUNTY:					
Standard Oil Co.	27	22	18	81	Kettelman North Dome
Wm. Riesener	5	23	20	1	
LOS ANGELES COUNTY:					
Standard Oil Co.	13	3	11	Emery 52	Coyote Hills
R. R. Bush Oil Co.	20	4	12	Bess 4	Long Beach
Dabney-Johnston Oil Corp.	24	4	13	87	Long Beach
Pernel Oil Corp.	19	4	12	Indian 1	Long Beach
H. F. Sturdevant	28	2	15	1	Playa del Rey
Continental Oil Co.	11	5	12	Bixby 35	Seal Beach
Durgin, Allen & Cosby	33	1	9	Stern 1	
Nelson S. Hogan	23	3	14	Nelson S. Hogan 1	
Palm Ridge Oil Co.	2	2	15	1	
Sanbar Petroleum Co.	35	5	16	1	
MONTEREY COUNTY:					
Thomas Petroleum Corp.	31	22	14	Flentge 1	
ORANGE COUNTY:					
Mineral Exploration Co., Ltd.	8	8	7	1	
SAN BERNARDINO COUNTY:					
Great American Petroleum Co.	18	2	8	Gapco 1	
Great American Petroleum Co.	18	2	8	Gapco 2	
Great American Petroleum Co.	18	2	8	Gapco 3	
SAN DIEGO COUNTY:					
San Felipe Oil Co.	25	11	8	Dauner 1	
SAN LUIS OBISPO COUNTY:					
Shell Oil Co.	4	25	12	Mahoney 1	

OIL FIELD DEVELOPMENT OPERATIONS—Continued

Company	Sec.	Twp.	Range	Well No.	Field
SAN MATEO COUNTY:					
Risden and Reed	21	6	5	Butts 2	
SANTA BARBARA COUNTY:					
J. M. Owen	28	4	27	Owen 1	Mesa
Pacific Gulf Oil, Inc.	28	4	27	2	Mesa
Casitas Oil Co.	34	4	25	202-2	
STANISLAUS COUNTY:					
Northern Petroleum Corp.	34	1	10	1	
SUTTER COUNTY:					
The Buttes Oilfields. Inc.	35	16	1	Buttes 1	
TULARE COUNTY:					
Hayman Oil Co.	17	23	28	1	
VENTURA COUNTY:					
Honolulu Oil Corp., Ltd.	23	3	24	Valenzuela 1	Rincon
Indian Petroleum Corp.	7	3	24	Shudde 2	Rincon
Hardison & Temple	22	4	21	1	Santa Paula
Merchants Petroleum Co.	1	4	20	6	Sespe
Charles and Hoxie Anderson	36	3	18	Marr 11	Simi
Associated Oil Co.	26	3	23	V. L. & W. 21	Ventura
Associated Oil Co.	26	3	23	V. L. & W. 26	Ventura
General Petroleum Corp.	28	3	23	Barnard 15-A	Ventura
Livermore & Kennedy	33	4	23	21	Ventura
Shell Oil Co.	29	3	23	Taylor 74	Ventura
G. L. Strobeck	34	4	23	Strobeck 1	Ventura

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of MINING IN CALIFORNIA.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of the new laws and official regulations and notices affecting the mineral industry.

ACQUIRING MINING CLAIMS THROUGH TAX TITLE

Frequent requests have come to the Division of Mines for information as to the method of purchasing lands (including patented mining claims) that have been 'sold to the State' for delinquent taxes. The necessary procedure is outlined in a circular letter issued from the office of the State Controller, Sacramento, excerpts from which follow:

All sections refer to the Political Code.

"There are two methods by which the State disposes of property which has stood unredeemed upon the delinquent tax rolls for five years. The same general laws govern the sales in each case; that is, notice of sale must be given to the delinquent owner by registered mail and by publication. The owner has the right to redeem by paying all the taxes, penalties, costs, interest, redemption penalties and expenses of notice, up to the hour of sale which is at auction to the highest bidder for cash. All sales are made by the tax collector of the county wherein the land is situated; and he, acting as agent for the State, makes the deed to the purchaser from the State.

"*The First Method* of purchase is under section 3771*a* which authorizes the tax collector to sell at public auction, to the highest bidder, for cash, all property which was sold to the State five years previous to date set for sale, and had not been redeemed from such sale nor canceled by the Board of Supervisors. The least acceptable bid at such sale is the amount of the taxes, penalties and costs, which were a charge at the time of the original delinquency and sale to the State. The purchaser has thirty days in which to redeem from any subsequent delinquencies against the property by payment of all taxes, penalties, costs, interest and redemption penalties and charges as provided for in sections 3817 and 3785*b*. If he fails to make said redemption within the time specified, he loses all right in and to the property and the owner's right to redeem is restored. These sales take place late in June or early in July in each county of the State where such delinquent properties appear upon the rolls. If you make that request and enclose ten cents (10c) to cover the cost, the tax collector will mail you a copy of the list to be sold. You will then have time to look up any piece in which you may be interested.

In case there be no purchaser at auction sale, the property is deeded to the State under section 3785. It will then be subject to sale by the State under the second method.

"*The Second Method* covers sales of tax deeded lands. That is, property which has stood delinquent on the rolls of the county for a period of five years and no redemption has been made or sale at auction held under the first method. These deeds of record are on file from each county of the State and such property is subject to sale under section 3897. The party seeking to buy lands in this class must make

a deposit in advance to cover the costs of sale with the tax collector of the county wherein the land is situated. Such officer, upon request, will then be authorized by this department to arrange for the sale at auction. Notice by publication and registered mail must be given the delinquent owner at least twenty-one days before the date set for sale. The least acceptable bid at the sale is the total of all the taxes, penalties and costs together with interest and redemption penalties computed upon the taxes for each year delinquent, up to and including the lien for the taxes of the year the deed was made to the State, plus the costs of sale. Should the party who made the deposit to defray the expenses of the sale be outbid thereat, such sum must be refunded before the tax collector will make the purchaser a deed to the property. When it is found that the total of taxes, interest, penalties and costs exceeds the value of the land, the Board of Supervisors may, by resolution, name a lesser sum which may be bid at sale in lieu of the total as given above—plus the costs of sale.

"All bidding is competitive. The same notices are required for each method outlined.

"The Controller also has the right to lease tax deeded lands. Any such lease, however, will terminate upon redemption being made by the owner as such right is not lost until the State sells the land.

"The Controller has no definite knowledge of the value, character or relative location of the property, nor can he know the condition of title. The State can only dispose of such title as it received by the deed to the State. The prospective buyer must inform himself as to these matters.

"The State does not guarantee title or give possession; neither does it furnish lists of these properties, nor does any county official. Such lists can be made from the deeds on file in the Controller's or the county recorders' offices, preferably the latter. All steps in the sales, as above noted, are taken by the officials of the county wherein the land is situated."

BIENNIAL REPORT OF THE STATE MINERALOGIST

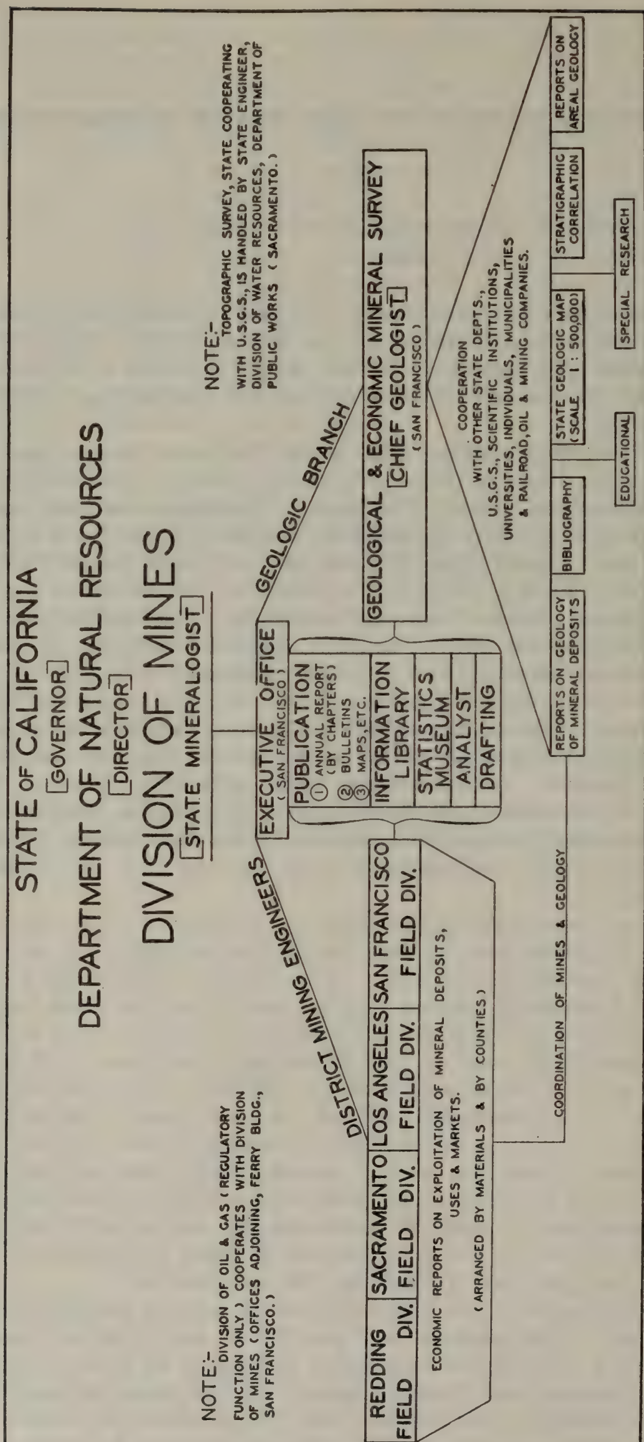
To His Excellency, HON. JAMES ROLPH, JR.,
Governor of California.

SIR: Herein I have the honor to present the biennial report of the State Mineralogist as required by law (Stats. 1913, Chap. 679) covering the work and activities of the State Division of Mines of the Department of Natural Resources, for the period July 1, 1930, to June 30, 1932.

Gratifying progress has been made, and continues, in carrying on the program outlined in the report of the preceding biennium. Details are given elsewhere herein. The greatly depressed economic conditions, which have been not only nation-wide, but world-wide, have enormously increased the demand upon the services and facilities of the division of mines, and for knowledge of the mineral resources of California. This is especially true of our gold districts. The most striking bit of evidence of this, was the exhaustion, almost overnight, of the April, 1932, quarterly chapter of the State Mineralogist's Report, because of information contained therein relative to gold placer mining methods and areas. The edition of 3000 copies (normally we print 2000) was entirely gone in three weeks from the time it was received from the state printer. Arrangements were subsequently made for the reprinting of an additional 3000 copies. In addition, over 4000 copies of mimeographed pamphlets have also been distributed, giving summarized information on placer mining, mining law, and quartz vein prospecting.

During the past two years many people have come to this Division in quest of information on the use of the miner's pan, and how to proceed in the search for gold. The number calling daily for such advice and knowledge became so great that a regular class was started in our laboratory in the Ferry Building; and, in order not to interfere with the analytical work in the laboratory, the hour of 3 to 4 p.m. daily was set. A count was kept for the first twelve days—120 took advantage of the assistance offered, in that time. Instructions are given in the use of the miner's pan; the amalgamating and retorting of gold; how to look for, and to recover gold from our gold-bearing streams. From an hour to an hour and a half is thus taken up in demonstrating and answering questions, by our mineral technologist, Mr. Frank Sanborn. He has assisted at least a thousand people in the use of the gold-pan, during the last two seasons.

In consequence of the large number of persons panning and washing for gold in the streams and gulches of our hills and mountains, and requiring avenues through which to dispose of their pannings, the number of ore-buyers' licenses issued by the state mineralogist has greatly increased. Previous to 1931, the number of licenses ranged around 25 to 30 each year. For 1931, there were 50. Thus far for


STATE OF CALIFORNIA
[GOVERNOR]
DEPARTMENT OF NATURAL RESOURCES
[DIRECTOR]
DIVISION OF MINES
[STATE MINERALOGIST]
NOTE:- DIVISION OF OIL & GAS (REGULATORY FUNCTION ONLY) COOPERATES WITH DIVISION OF MINES (OFFICES ADJOINING, FERRY BLDG., SAN FRANCISCO.)
NOTE:- TOPOGRAPHIC SURVEY, STATE COOPERATING WITH U.S.G.S., IS HANDLED BY STATE ENGINEER, DIVISION OF WATER RESOURCES, DEPARTMENT OF PUBLIC WORKS (SACRAMENTO.)
DISTRICT MINING ENGINEERS
GEOLOGIC BRANCH
EXECUTIVE OFFICE (SAN FRANCISCO)
PUBLICATION
1 ANNUAL REPORT (BY CHAPTERS)
2 BULLETINS
3 MAPS, ETC.
INFORMATION LIBRARY
STATISTICS MUSEUM
ANALYST
DRAFTING
REDDING FIELD DIV.
SACRAMENTO FIELD DIV.
LOS ANGELES FIELD DIV.
SAN FRANCISCO FIELD DIV.
ECONOMIC REPORTS ON EXPLOITATION OF MINERAL DEPOSITS, USES & MARKETS.
(ARRANGED BY MATERIALS & BY COUNTIES)
COORDINATION OF MINES & GEOLOGY
GEOLOGICAL & ECONOMIC MINERAL SURVEY
[CHIEF GEOLOGIST]
(SAN FRANCISCO)
COOPERATION WITH OTHER STATE DEPTS., U.S.G.S., SCIENTIFIC INSTITUTIONS, UNIVERSITIES, INDIVIDUALS, MUNICIPALITIES & RAILROAD, OIL & MINING COMPANIES.
REPORTS ON GEOLOGY OF MINERAL DEPOSITS
BIBLIOGRAPHY
STATE GEOLOGIC MAP (SCALE 1 : 500,000)
STRATIGRAPHIC CORRELATION
REPORTS ON AREAL GEOLOGY
EDUCATIONAL
SPECIAL RESEARCH

1932, we have issued 91. Of these 45 are for licenses permitting aggregate of purchases up to $1,000 for the year (fee $2), and 46 for the 'unlimited' license (fee $15). This does not segregate the 10 branches of the Bank of America buying under a single license issued to the parent corporation. The records of the U. S. Mint at San Francisco show the total number of separate 'deposits' of gold bullion, dust, etc., of 16,000 for the fiscal year ended June 30, 1932, as against under 9000 for the fiscal year ended June 30, 1931. The Mint does not accept less than $40 in a single deposit, so that practically all of these small placer operators with their few grains a day would be unable to dispose of their meager washings except for our licensed gold buyers situated in their local communities close to the 'diggings.' Many of these are general merchandise stores, where the transaction is essentially that of exchanging food and clothing over the counter for the gold grains. In 1931 our licensees reported to this office a total of 9050 separate purchases of gold in varying amounts. For the first 6 months of 1932, the number reached 10,200. Single purchases as low as 27 cents have been reported. These licensees are rendering a truly public service in this time of stress. We found on a check-up in June, 1932, that they are for the most part quite liberal, even charitable at times, with these small transactions. On the whole, their profits in the gold-buying business are relatively small, not exceeding 40 cents or 50 cents per day per man, average. It is estimated that there were some ten thousand in 1931, and from twelve to fifteen thousand persons, including even some women and children, during the spring and summer of 1932, thus engaged in small-scale, hand-placer mining in California.

"The time to mine gold is in hard times"—so stated Dean John W. Finch of the Idaho School of Mines, before a meeting of the United States Chamber of Commerce at its session in San Francisco, this year. The work of the division of mines and the demand upon our facilities and service have as already pointed out doubled and trebled in these months. All of our offices (but especially at San Francisco and Los Angeles), have been at times well-nigh swamped by inquirers and by letters seeking data and information on California's resources. Frequently they are standing in line waiting to have an interview. Fifty to a hundred have been served in a single afternoon. At the Los Angeles office on the first day the placer bulletin above referred to was put on sale, there was a line of people extending out of the office and down the hallway of the building.

During the calendar year 1930, there was reported commercial production of fifty-one different mineral substances having a total value in the crude state of $365,604,695, being a decrease of $66,643,533 from the 1929 total of $432,248,228, due principally to a nearly fifty million dollar drop in petroleum. In 1931, there was a still further drop to $215,964,420, likewise due to petroleum being less both in quantity and unit value. Gold yield increased approximately a million dollars in 1930 over the 1929 figures and another million-and-a-quarter in 1931. Copper, silver, lead, and zinc decreased. Quicksilver increased in 1930, but dropped back slightly in 1931. The structural, industrial, and salines groups showed principally decreases.

The progress being made under our geological survey program is highly gratifying, even to the point of embarrassment, because of

the insufficiency of funds for printing reports and maps already available for publication. The appropriation of the division of mines has been called upon to meet only a fraction of the cost of the field work and the preparation of these reports; and unless the allottment for printing is increased for this branch for the coming biennium, the state stands to lose a considerable part of the investment which it has already made. It should be borne in mind that this work is not only cooperative with other agencies engaged along similar lines, but that it is also coordinated with the economic development surveys of the mining division and with geological investigations of such other state agencies as the highway department, the water resources division and the state engineer's office.

In a progress report to the state mineralogist under date of April, 1932, Mr. Olaf P. Jenkins, chief geologist, states:

''It is most gratifying to report that not only those projects which have been started by the Geologic Branch of the California State Division of Mines have progressed very successfully, but several other projects have been carried out or arranged for future work. All the work so far done, represents whole-hearted cooperation of other interests besides those of the State.

''The only stumbling block in the way of progress is the lack of sufficient funds to handle all or even half of the fine cooperative projects offered to the State in behalf of desired geological study of the problems in California.

''The funds needed are for the following kinds of expenditures:

1. Publication of worthy reports which are offered as contributions.

2. Publication of reports which are prepared under the auspices of the Geologic Branch of the Division of Mines.

3. Publication of final engraved geologic maps of the highest order, contributed or prepared through cooperation.

4. Field expenses during summer or working months only, of capable, experienced geologists of high standing who contribute their time and who write their reports on their own time and expenses during the university year.

5. Part field expenses during summer months of capable, experienced geologists who not only contribute their time but a large part of their own living expenses while in the field.

6. Funds for preparation of material for laboratory study, such as thin and polished sections of minerals and rocks.

7. Funds for making quantitative chemical analyses to accompany reports in preparation.

8. Funds for field and office equipment, mapping materials, photographic supplies, etc.

9. Funds for general maintenance and running expenses of the permanent geological staff, which consists only of a chief geologist and his secretary, rated a 'geological clerk' and having the training of a geologist.

10. Funds for permanent employment of a geological draftsman.

''The greatest care has been maintained at all times in cutting down expenses. In nearly all of his own field work, the Chief Geologist has secured the voluntary assistance of some other geologist, who

has either paid his own expenses or the two geologists have lived in such an inexpensive manner that one modest expense account has served for both.

"Field notes of the Chief Geologist have been kept in visual form as a series of mounted photographs, labelled in such a manner that any one may make use of them.

"A journal is prepared from day to day which records not only the activity of the Geologic Branch, but geologic activity in general, where California is involved.

"The large state geologic map in preparation is well advanced. The Federal Survey is cooperating in its compilation, while a large number of private individuals contribute material to it.

"A general geographic study is also being carried on in view of preparing a geographic and topographic map of the state which will accompany the geologic map.

"A general report on geologic history and correlation of formations is in preparation by the Chief Geologist.

"The following geologic reports have been published in Mining in California since the Geologic Branch started activities:

1. October, 1930. Preliminary report of the geology of southwestern Mono County, California, by Evans B. Mayo.

2. January, 1931. Preparation of a new relief map of California, by H. A. Sedelmeyer.

3. April, 1931. Stratigraphic significance of the Kreyenhagen shale of California, by Olaf P. Jenkins.

4. April, 1931. Diatoms and silicoflagellates of the Kreyenhagen shale, by G. D. Hanna.

5. April, 1931. Foraminifera of the Kreyenhagen shale, by C. C. Church.

6. April, 1931. Preliminary report of the geology of Santa Cruz Island, Santa Barbara County, California, by William W. Rand.

7. October, 1931. Geology of the San Jacinto quadrangle south of San Gorgonio Pass, California, by Donald M. Fraser. In addition to these publications in MINING IN CALIFORNIA, Dr. Solon Shedd prepared Bulletin No. 104, which was published as a preliminary edition of a bibliography of the geology and mineral resources of California to the end of 1929, in March, 1931.

"The following geologic reports are in press: *

1. Sediments of Monterey Bay, by E. Wayne Galliher, to be published in the January, 1932, MINING IN CALIFORNIA.

2. Geology and physical properties of building stone from Carmel Valley, California, by E. Wayne Galliher, to be published in the January, 1932, MINING IN CALIFORNIA.

3. Bibliography of the geology and mineral resources of California (revised and with index), by Solon Shedd, Bulletin No. 104.

---

* In addition to this list the following geologic reports appear in this issue (July-October) of MINING IN CALIFORNIA:

1. Jenkins, Olaf P., Report accompanying geologic map of northern Sierra Nevada.
2. Chaney, Ralph W., Notes on occurrence and age of fossil plants found in the auriferous gravels of Sierra Nevada.
3. Blackwelder, Eliot, Glacial and associated stream deposits of the Sierra Nevada.
4. Anderson, Frank M., Jurassic and Cretaceous divisions in the Knoxville-Shasta succession of California.
5. Murphy, F. M., Geology of part of the Panamint Range, California.

The following geologic projects are under way:

1. Weaverville quadrangle (Shasta and Trinity counties), by N. E. A. Hinds.
2. Elizabeth Lake quadrangle (Los Angeles and Kern counties), by E. C. Simpson.
3. Searles Lake quadrangle (San Bernardino, Inyo, and Kern counties), by C. D. Hulin.
4. Sebastopol and Duncans Mills quadrangles (Sonoma and Marin counties), by F. A. Johnson.
5. Amboy quadrangle (San Bernardino County), by J. C. Hazzard.
6. Newberry and Ord Mountains (San Bernardino County), by Dion Gardner.
7. Northeastern Madera County, by Homer Erwin.
8. A study of the Cretaceous beds on the west side of the Sacramento Valley, by F. M. Anderson.
9. Geology and ore deposits of the Julian District, San Diego County, by Maurice Donnelly.
10. Geology of the Lucia quadrangle (Monterey County), by Parry Reiche.
11. Underground geology of the mines about Bodie (Mono County), by Francis H. Frederick.
12. Sand deposits of California, by E. Wayne Galliher.
13. Geology and mineral deposits of the borax district about Kramer (San Bernardino County), by A. A. Fitch.
14. Geology of north central California, by R. Dana Russell.
15. Physiography of the region about Clear Lake (Lake County) together with a study of other Californian lakes, by W. M. Davis.
16. Geology in the region of Del Norte County, by Harry MacGinitie.
17. Geology of a part of the Panamint Range, Inyo County, by F. M. Murphy.
18. Underground geology of the coast tunnels of the Hetch Hetchy Project (Alameda County), by George Green.
19. Geology and ground water problem of the San Joaquin Valley (Fresno County), by Zenas Melcon.

"With the exception of Dr. Hulin's work in the Searles Lake quadrangle, which was started before the Geologic Branch was established, no salaries have been paid for any of this work. The money provided Dr. Shedd in addition to clerical help has all practically gone into the expenses of the undertaking. In practically every other case the geologist has contributed not only all of his time, but a large part of his own field expenses.

"The following table shows a list of detailed projects, the actual amount paid by the Division of Mines for traveling expenses, and a very conservative estimate of the value of the contributions of time and expenses by these men, or in other words the amount the Division would have paid, had a small salary and full expenses been allowed for each field season. It does not take into account the cost of preparing the report nor the work involved in the laboratory. In Dr. Shedd's case, however, all the work was in the library.

"In a number of these cases several previous field seasons had already been given to their specific surveys, and these men included

that work in their donations to the Division of Mines without any cost to the State.

(*Including budget for 1932, summer*)

Detailed Project	*Geologist*	*Actual field expenses to State*	*Estimated value of contributions of time and expenses by geologist*
Weaverville	Hinds	$1,836 54	$8,000 00
Elizabeth Lake	Simpson	1,096 12	3,300 00
Sebastopol, Duncans Mills	Johnson	424 75	2,000 00
Amboy	Hazzard	1,611 55	3,500 00
Newberry and Ord Mts.	Gardner	1,372 87	2,400 00
Madera County	Erwin	1,189 98	3,000 00
Mono County	Mayo	810 04	4,800 00
Santa Cruz Island	Rand	Nothing	2,300 00
San Jacinto	Fraser	375 00	3,100 00
Monterey Bay	Galliher	Nothing	2,000 00
Carmel Stone	Galliher	150 00	1,000 00
Bibliography	Shedd	500 00	6,000 00
Lucia	Reiche	100 00	2,000 00
Bodie	Frederick	250 00	2,000 00
Sand	Galliher	100 00	1,200 00
Kramer	Fitch	200 00	1,200 00
North central California	Russell	Nothing	3,000 00
Clear Lake	Davis	Nothing	800 00
Del Norte	MacGinitie	Nothing	1,000 00
Panamint	Murphy	Nothing	3,600 00
Coast tunnels	Green	183 34	1,000 00
San Joaquin Valley	Melcon	Nothing	1,000 00
Julian District	Donnelly	100 00	1,000 00
Totals		$10,300 19	$61,000 00

"The Geologic Branch has been offered over 25 other cooperative projects of similar nature but has had insufficient funds to start them.

"It must be understood that the $10,300.19 does not include the projects of the permanent staff of the Geologic Branch, such as the project of the State geologic map, nor the expense of publication, office equipment, etc.

"It may readily be seen that the Division of Mines is getting many times more value than it pays in expenses. This method of work has been made possible only by securing the confidence and good will of technical persons, scientific bureaus, universities, commercial concerns, etc. It has been through careful administration at all times that the program of work has been successfully carried forward.

"The Division of Mines is making available to the State the accumulated knowledge and experience of recognized geologists not only in one institution in California but in many. From other states much cooperative assistance is likewise being gained. Such universities as Cornell, Columbia, and Yale are working with the Geologic Branch.

"Supervision of the work is maintained not only through careful direction of the geological departments of these various universities, but through personal guidance of the Chief Geologist of the Division of Mines.

"In addition to these contributions from universities and individuals there have been many accurate geological maps contributed by various commercial concerns. The Geological Department of the Southern Pacific Company has given to the Division a vast amount of geological unpublished data in the form of maps which have taken the company over 20 years to accumulate. The geologic map of the Shasta quadrangle, accompanying Charles V. Averill's economic report, and published in MINING IN CALIFORNIA January, 1930, is one example.

"It is highly desirable that the Geologic Branch of the Division of Mines cooperate with other divisions of the State, especially with the following:

1. Division of Water Resources.
2. Division of Highways.

"Much usable information could be given to these divisions and also much could be gained for the Division of Mines to publish and therefore make available to the public.

"It may readily be seen that a State geological survey represents a bureau of research of an order so broad that its field of activities stretches over a vast number of interests and industries, many of which are not directly related to 'Mining.' In order to gain the best use of a geological survey, the State should give it more chance to use the opportunities that are constantly placed before it.

"In these times of economic depression, the most can be gained from research workers, laboring without pay, with their only view that of contributing for publication carefully prepared professional papers of permanent value. It would be poor economy not to advance this study and give it a chance for progress. The work is absolutely free of selfish interests but full of interest to a very large number of persons in various walks of life. It is useful, a lasting record of value, a source of constant reference, and a stimulus to more thoughtful progress in industry and education. It is now well recognized that well-done geology is fundamental in the progress of civilization."

In the normal developmental program of the division concerned primarily with the economic mineral resources, the surveys have completed the series on the basis of county areas, and state-wide reports on specific substances commenced. Of the former during the biennium, reports have been published on the mineral resources of Yuba, San Bernardino (two, because of exhaustion), Butte, Kings, Tulare, Alpine. Of the latter, a detailed report on the feldspar and silica resources of California. The special bulletin on "American Mining Law" by A. H. Ricketts of the San Francisco Bar was printed and made available for distribution. This work bids fair to become a classic on this subject., and reflects much credit upon the State Division of Mines as well as upon its author. Many complimentary remarks and letters have been received, and its sale is nation-wide. In its preparation, Mr. Ricketts was most untiring in his energy applied to the task which covered a period of nearly seven years, and likewise painstaking in his attention to details and the desire to obtain the utmost possible accuracy.

Publications.

Publications issued July 1, 1930, to June 30, 1932:

July and October chapters of State Mineralogist's Report XXVI, 1930. Among the more important subjects included were:

Mineral resources of Yuba, San Bernardino, Butte, Kings and Tulare counties.

Special articles on: Commercial Grinding Plants in California; Biennial report of State Mineralogist; Geology of Southwestern Mono County.

State Mineralogist's Report XXVII, 1931, containing special articles on:

Economic geology of Shasta Quadrangle; Beryllium and Beryl; The New Tariff on Nonmetallic Products; Crystalline Talc; Decorative Effects in Con-

crete; Cyanide Treatment of Gossan, Shasta County; Stratigraphy of the Kreyenhagen Shale; Diatoms and Silicoflagellates of the Kreyenhagen Shale; Foraminifera of the Kreyenhagen Shale; Geology of Santa Cruz Island; Feldspar, Silica, Andalusite, and Cyanite Deposits of California; Andalusite in Mono County; its occurrence and chemical importance; Bill creating Trinity and Klamath River Fish and Game District and its effect upon Mining; Geology of San Jacinto Quadrangle south of San Gorgonio Pass; Notes on Mining Activity in Inyo and Mono Counties in July, 1931.

Mineral Resources of Yuba, San Bernardino, and Alpine Counties.

January and April chapters of State Mineralogist's Report XXVIII, 1932, containing special articles on:

Economic Mineral Deposits of the San Jacinto Quadrangle; Geology and Physical Properties of Building Stone from Carmel Valley; Contributions to the Study of Sediments; Sediments of Monterey Bay; Sanbornite, a new mineral from California; Elementary Placer Mining Methods and Gold Saving Devices; The Pan, Rocker, and Sluice Box; Prospecting for Vein Deposits; Bibliography of Placer Mining.

Bulletin 98. American Mining Law, by A. H. Ricketts, 811 pages, 23 illustrations, flexible leather pocketbook.

Bulletin 103. Mineral Production of California for 1929, by Henry H. Symons, 231 pages, 16 illustrations. Gives detailed figures of commercial production of all mineral substances in California for calendar year 1929.

Bulletin 104. Bibliography of the Geology and Mineral Resources of California to the end of 1929 (Preliminary edition—to be revised in final form to end of 1930), by Solon Shedd, 205 pages.

Bulletin 105. California Mineral Production and Directory of Mineral Producers, for 1930, by Henry A. Symons, 231 pages, 14 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year 1930.

Bulletin 106. Manner of Locating and Holding Mineral Claims in California (with forms), by A. H. Ricketts, 20 pages.

Because of the increased demands upon the services and facilities of the Division of Mines, previously described in this report, we could well justify an increase in the appropriation request for the coming biennium; but in our economic development work, by a careful weighing of each item, one against the other, we estimate that we can get by and still render a reasonable part of the service demanded of this Division, within an amount slightly less than the allotment for the current biennium.

The outstanding need, however, both in that branch and the geological work, is a considerably more liberal allowance for printing the results of field studies already made, as well as those in course of pursuit. This is not a new situation. It has confronted State mineralogists before the incumbent. Much valuable material has been lost to the Commonwealth or its practical value reduced greatly by lack of or delay in publication. At the present time, this condition is particularly acute. The most important of these pending reports is a bulletin upon the Mother Lode Gold Belt, on which Mr. C. A. Logan, District Mining Engineer, has been engaged for the past five or six years and is now ready to send to the printer. We could be selling hundreds of copies of this bulletin, if we had it printed, because of the renewed interest in gold mining. It should be borne in mind that the money spent in printing these reports of the Division of Mines comes back to the State Treasury, as the books are sold at a price which approximates the cost of printing. The geological reports ready, or nearly so, for

publication cover important and widely distributed areas from San Diego to Siskiyou.

It can not be too strongly emphasized that the functions of the Division of Mines are developmental and bring a capital into California, building up industries and pay rolls and providing active taxable properties. Not only that, but in the present time of stress this Division has been particularly indispensable and helpful to the many thousands of unemployed who are seeking (and finding in a greater or less measure) a living in the placer gold districts.

Respectfully submitted.

WALTER W. BRADLEY,
State Mineralogist.

San Francisco, September 13, 1932.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel.

There have been no changes of personnel during the past three months to be noted.

New Publications.

There has been such an unprecedented demand for information and data on gold mining (especially placer mines and placer methods) this year that the April, 1932, chapter of 'Mining in California,' noted below was out of stock in three weeks from the time we received it from the printer. This, too, in the face of the fact that we had 3000 copies instead of the normal edition of 2000 copies. By special arrangement with the State Department of Finance, it has since been reprinted and is now available.

'Mining in California' (quarterly), January and April, 1932, being Chapters 1 and 2 of the State Mineralogist's Report XXVIII, price 25 cents.
January contains: "Economic Minerals of the San Jacinto Quadrangle"; "Contributions to the Study of Sediments"; "Geology and Physical Properties of Building Stone from Carmel Valley"; "Sediments of Monterey Bay"; "Sanbornite a Newly Described Mineral from California"; Topographic Mapping Program for California"; "Tariff Rate Changed on Feldspar."
April issue contains: "Elementary Placer Mining Methods and Gold-Saving Devices"; "The Pan, Rocker, and Sluice Box"; "Prospecting for Vein Deposits"; "Selected Bibliography on Placer Mining."

Commercial Mineral Notes, Nos. 109, 110, 111, 112, 113, 114, May, June, July, August, September, October, 1932, respectively. These 'notes' contain the lists of 'mineral deposits wanted,' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet, monthly. It is mailed free to those on the mailing list for 'Mining in California.' As an evidence of the interest in mines and minerals now showing considerable activity, this mimeographed 'sheet' has had to be expanded in recent months to two pages.

Mails and Files.

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

HENRY H. SYMONS, Statistician and Curator

STATISTICS

The total value for the mineral output for California for the year 1931 was $215,964,420, being a decrease of $149,640,275 from the total of 1930 of $365,604,695. There were fifty-three different mineral substances exclusive of a segregation of the various stones grouped under gems; and all but one of the fifty-eight counties of the State contributed to the list.

As revealed by the data following, the salient features of 1931 compared with the previous year were: A material decline in the amount and value of the petroleum output, with notable decreases in amounts and values of natural gas, miscellaneous stone, cement, copper, brick, and hollow building tile; and potash. Increases were registered by gold, borax, limestone and salt. Petroleum showed a decrease in value of $129,863,323. There was a decrease from 227,328,988 barrels to 188,270,605 barrels. This decrease was partly due to a curtailment program and extremely low prices paid for the lighter-gravity crude oils. Natural gas showed an increased output with a decreased value from 315,513,952 M. cu. feet worth $24,559,840, to 344,959,920 M. cubic feet worth $16,690,695.

Of the metals the gold yield increased in value from a total of $9,451,162 to $10,814,162, and platinum from 217 fine oz. worth $11,700 to 350 fine oz. worth $11,979. Decreased values were registered by all other metals, copper from 26,534,752 lbs. worth $3,449,522, to 12,954,842 lbs. worth $1,178,890; quicksilver from 11,374 flasks worth $1,255,257 to 13,478 flasks worth $1,121,624; silver from 1,622,803 fine oz. worth $624,779 to 867,818 fine oz. worth $251,667; and lead from 3,524,796 lbs. worth $176,241 to 3,934,240 lbs. worth $145,568. A small amount of zinc was mined commercially for the first time since 1927. The increase in the gold output was due to increased activity in both lode and placer mines. All metals other than gold reached prices so low it would not pay to mine them.

Of the structural materials, all items showed decreased values with the exception of chromite and bituminous rock; cement decreased from 9,831,938 bbls. worth $14,575,731 to 7,693,712 bbls. worth $11,510,655; brick and hollow building tile from a total value of $4,205,460 to $2,560,415; miscellaneous stone $16,430,027 to $11,848,531 and granite from $855,477 to $636,741.

Of the industrial minerals the total value decreased from $7,168,522 to $4,741,939; increases in value of annual productions were registered by barytes, bentonite (fullers earth), feldspar, gems, limestone, and silica; while all other minerals in the group showed a decreased

value. The salines were the only group that showed an increase in total value, being from $9,943,500 to $11,779,513. Producers received more for salt and borates than they did in 1930, and iodine was added to the group which more than offset the decrease in all other materials under this classification.

The distribution of the 1931 output of California by substance is shown in the following tabulation:

Substance	Amount	Value
Barytes	27,682 tons	$156,647
Borax	206,405 tons	5,753,037
Brick and hollow building tile		2,560,415
Bentonite (fullers earth)	13,960 tons	222.583
Cement	7,693,712 bbls.	11,510,655
Chromite	441 tons	6,737
Clay (pottery)	332,680 tons	408,931
Coal	12,551 tons	77,607
Copper	12,954,842 lbs.	1,178,890
Feldspar	4,795 tons	59,921
Gems		5,607
Gold		10,814,162
Granite		636,741
Gypsum	88,354 tons	199,198
Lead	3,934,240 lbs.	145,568
Lime	36,189 tons	360,523
Limestone	177,268 tons	560,699
Magnesite	21,576 tons	182,283
Marble (onyx and travertine)		81,760
Mineral water	26,164,331 gal.	1,347,860
Natural gas	344,959,920 M. cu. ft.	16,690,695
Petroleum	188,370,605 bbls.	141,835,723
Platinum	350 oz.	11,979
Pumice and volcanic ash	11,711 tons	108,130
Pyrite	25,402 tons	131,174
Quicksilver	13,478 flasks	1,121,624
Salt	330,951 tons	1,233,567
Sandstone		30,960
Silica (sand and quartz)	43,330 tons	182,769
Silver	867,818 fine oz.	251,667
Soapstone and talc	13,472 tons	109,940
Soda	78,701 tons	1,217,811
Stone, miscellaneous[1]		11,848,531
Zinc	149,865 lbs.	5,314
Unapportioned[2]		4,914,712
Total value		$215,964,420

[1] Includes macadam, crushed rock, ballast, rubble, riprap, sand and gravel.

[2] Includes bituminous rock, bromine, calcium chloride, diatomite, dolomite, iodine, iron ore, manganese ore, mica, mineral paint, sillimanite-andalusite-cyanite group, potash, slate, tube-mill pebbles, paving blocks, sulphur, tungsten.

Distribution by counties is given in the following tabulation:

Alameda	$2,417,925	Placer	$285,848
Alpine	29	Plumas	1,559,296
Amador	2,170,075	Riverside	2,526,503
Butte	482,737	Sacramento	2,259,674
Calaveras	1,093,554	San Benito	654,284
Colusa	118,905	San Bernardino	9,975,484
Contra Costa	1,328,812	San Diego	852,447
Del Norte	38,075	San Francisco	20,500
El Dorado	437,935	San Joaquin	462,196
Fresno	2,238,333	San Luis Obispo	400,135
Glenn	47,462	San Mateo	2,230,509
Humboldt	199,986	Santa Barbara	12,714,760
Imperial	528,027	Santa Clara	666,300
Inyo	1,347,708	Santa Cruz	1,767,134
Kern	28,782,358	Shasta	666,086
Kings	17,371,901	Sierra	691,365
Lake	280,768	Siskiyou	187,007
Lassen	1,843	Solano	62,270
Los Angeles	79,469,897	Sonoma	252,636
Madera	488,343	Stanislaus	277,281
Marin	544,760	Sutter	----------
Mariposa	193,641	Tehama	50,407
Mendocino	72,707	Trinity	328,522
Merced	707,789	Tulare	197,116
Modoc	181,250	Tuolumne	377,157
Mono	201,923	Ventura	15,455,727
Monterey	223,470	Yolo	21,500
Napa	396,841	Yuba	1,022,826
Nevada	3,497,218		
Orange	15,135,148	Total	$215,964,420

MUSEUM

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America, and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other States and foreign countries as well.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

LABORATORY

FRANK SANBORN, Mineral Technologist

Many thousand prospectors and others have taken advantage of the assistance which is offered by the Laboratory of the Division of Mines, and a steady increase in the number of samples received by this department is evident. In addition to the identification of minerals, assistance is given in finding a market for those having commercial possibilities.

LIBRARY

HERBERT A. FRANKE, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains some five thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, MINING IN CALIFORNIA contains under this heading a list of all books and official reports and bulletins received, with names of publishers or issuing departments.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED

Governmental, National:

U. S. Geological Survey:

Bulletins:

830-A—Copper Deposits near Keating, Oregon. By J. Gilluly.
832 —The Crystal Cavities of the New Jersey Zeolite Region. By W. E. Schaller.
833 —Mineralogy of Drill Cores from the Potash Field of New Mexico and Texas. By W. T. Schaller and E. P. Henderson.
836-C—Surface Water Supply of Southeastern Alaska, 1909–1930. By F. F. Henshaw.
838 —Nitrate Deposits of the U. S. By G. R. Mansfield and L. Boardman.

Professional Papers:

172 —Gold Quartz Veins of the Alleghany District, California. By H. G. Ferguson and R. W. Gannett.

Water Supply Papers:

638-B—Water Resources of the Rogue River Drainage Basin, Oregon.
638-D—Quality of Water of the Colorado River in 1928–1930.
638-C—Outline of Methlods for Estimating Ground-Water Supplies.

682 —Part II. South Atlantic Slopes and Eastern Gulf of Mexico Basins.
683 —Part III. Ohio River Basin.
685 —Part V. Hudson Bay and Upper Mississippi River Basins.
686 —Part VI. Missouri River Basin.
692 —Part XII. North Pacific Slope Drainage Basins.
696 —Part I. North Atlantic Slope Drainage Basins.
699 —Part IV. St. Lawrence River Basin.
701 —Part VI. Missouri River Basin.
702 —Part VIII. Lower Mississippi River Basin.
703 —Western Gulf of Mexico Basins.
706 —Part XI. Pacific Slope Basins in California.
707 —Part XII. Pacific Coast Basins in Washington and Upper Columbia River Basin.
708 —Part XII. North Pacific Slope Drainage Basins.

U. S. Bureau of Mines:

Bulletins:

304—Ochers and Mineral Pigments of the Pacific Northwest. By H. Wilson.
348—Paraffin and Congealing-Oil Problems. By C. E. Reistle, Jr.
349—Liquid-Oxygen Explosives. By G. St. J. Perrott and N. A. Tolch.
352—Safety Practices in California Gold Dredging. By S. H. Ash.
353—Tests of Rock-Dust Barriers in the Experimental Mine. By Rice, Greenwald and Howarth.

Economic Papers:

15—Molybdenum. By A. V. Peter.

Mineral Resources of the U. S.:

Coal in 1930.
Coke and By-Products in 1930.
Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1930.
Gold, Silver, Copper, Lead and Zinc in Nevada in 1930.
Lead in 1930.
Natural Gasoline in 1930.
Zinc in 1930.

Report of Investigations:

2998—Retreatment of Mother Lode Carbonaceous Slime Tails. By E. S. Leaver and J. A. Woolf.
3115—Consumption of Explosives in March, 1931. By W. W. Adams and L. W. Gerry.
3148—Concentration of the Rake Discharge from a Bowl Classifier in a Washing Plant of the Mesabi Range, Minnesota. By Fred D. DeVaney and Will H. Coghill.
3149—Salts in Tri-State Mill Waters: Their Ill Effect on the Flotation of Blende and Their Removal. By A. B. Campbell, Warren Howes and W. H. Ode.
3151—Use of Micropyrometer for High-Temperature Melting Point Investigations. By G. R. Fitterer and M. B. Royer.
3154—The Splicing of Rubber-sheathed Trailing Cables. By L. C. Ilsley and A. B. Hooker.
3163—Official Changes in the Active List of Permissible Explosives and Blasting Devices for February and March, 1932.
3164—Selecting and Training the Refinery Personnel to Prevent Accidents. By R. L. Marek.
3165—Retreatment of Fine Washed Coal from the Black Creek and Mary Lee Beds on Coal Washing Tables. By A. C. Richardson, G. D. Coe, H. J. Hager and R. Q. Shotts.
3166—Determination of Iron Oxide in Liquid Steel. By C. H. Herty, Jr., Hyman Freeman and M. W. Lightner.
3167—A Study of the Properties of Texas Polyhalite Pertaining to the Extraction of Potash. By J. E. Conley, F. Fraas and J. M. Davidson.
3168—The Determination of Volatile Matter in Low-Temperature Cokes, Chars and Noncoking Coals. By H. M. Cooper, F. D. Osgood and R. E. Solomon.

3169—Absorbents for Liquid Oxygen Explosives: Their Relation to Sensitiveness to Impact and Other Properties of L. O. X. By L. V. Clark, with an appendix by A. LaMotte.
3170—Washability Studies of the Brockwood Bed at the Warrier View Mine, Tuscaloosa, Ala. By A. C. Richardson, G. D. Coe and H. L. Anthony.
3171—Analytical Distillation of Coal Tar. By E. B. Kester, W. D. Pohle and L. P. Rockenbach.
3173—Some Methods of Separating Oil and Water in West Texas Fields, and the Disposal of Oil Field Brines in the Hendricks Oil Field, Texas. By R. E. Heithecker.
3174—Properties of Crude Oil from the Greasewood Flat Area in Colorado. By H. P. Rue.
3175—Motor Gasoline Survey August, 1931, Part II, Additional Data. By A. J. Kraemer, E. C. Lane and E. L. Garton.
3177—Migration of Injected Gas Through Oil and Gas Sands of California. By H. C. Miller.
3178—The Use of Lime in a Salt Solution for Removing Hydrogen Sulphide from Natural Gas. By Harold L. Rue.

Information Circulars:

6500—Geophysical Abstracts No. XXV. By Frederick W. Lee.
6553—Crushing and Grinding Limestone at the Howes Cave (New York) Plant of the North American Cement Corporation.
6554—Method and Cost of Quarrying, Crushing and Grinding Limestone at the Security Quarry of the N. A. Cement Corporation, Security, Md.
6555—Milling Methods at the Concentrator of the Walker Mining Company, Walkermine, Cal.
6556—250 Versus 500 Volts or More for Circuits in Gassy Coal Mines. By L. C. Ilsley.
6560—Pumice and Pumicite. By Paul Hatmaker.
6561—Quartz Gem Stones. By I. Aikens.
6562—Abrasive and Industrial Diamonds. By Paul M. Tyler.
6566—Chromium, General Information. By Lewis A. Smith.
6571—Fuels Consumed by the Federal Government during the Fiscal Year Ended June 30, 1930. By F. M. Shore, A. G. Charles and R. W. Metcalf.
6572—Vanadium. By Frank L. Hess.
6573—Milling Methods and Costs at the Concentrator of the Miami Copper Company, Miami, Arizona. By H. D. Hunt.
6574—Milling Methods at the Balmat Mill of the St. Joseph Lead Co., Balmat, St. Lawrence County, New York. By John B. Knaebel.
6577—Guarding Trolley Wires in Mine. By E. J. Gleim.
6578—Good Rock-Dusting and Ventilating Practice in Two Alabama Coal Mines. By F. E. Cash.
6579—Sodium and Potassium Metals. By Paul M. Tyler.
6584—Notes Pertaining to Safety Inspections of Permissible Electric Mine Equipment. By E. J. Gleim.
6587—Milling Methods and Costs at the Morning Concentrator of the Federal Mining and Smelting Co., Mullan, Idaho. By M. P. Dalton.
6588—Sinking Practice and Costs at the Pim Shaft, St. Louis Smelting and Refining Works of the National Lead Co., St. Francois, Mo. By Roy H. Poston.
6590—Milling Methods and Costs at the Page Concentrator of the Federal Mining and Smelting Co., Kellogg, Idaho. By G. S. Price.
6592—Methods and Costs of Mining and Preparing Gravel and Sand for Market at the Plant of the Seaboard Sand and Gravel Corp., Port Jefferson, N. Y. By Anderson Dana.
6595—Data in Reference to Installation of Cables in Shafts and Boreholes. By L. C. Ilsley and E. J. Gleim.
6596—Rock Dust Does Stop or Limit Mine Explosions. By D. Harrington.
6598—A Mechanically Driven Level Rock Tunnel. By W. D. Bryson.
6599—Quarrying Methods and Costs at the Sloan Quarry of the U. S. Lime Products Corp., Sloan, Nevada.
6600—Milling Methods and Costs at the Lead Concentratory of the Hecla Mining Co., Gem, Idaho. By W. L. Zeigler.

6601—Mining Methods and Costs at the Mt. Hope Mine of the Warren Foundry and Pipe Corp., Mt. Hope, N. J. By J. R. Sweet.
6602—Shaft-Sinking Methods, Practices and Costs of the Consolidation Coal Co., at Its No. 261 Mine, Caretta, McDowell Co., W. Va. By Laurence E. Kelley.
6603—Method and Cost of Quarrying Limestone at the Milltown Quarry of the Louisville Cement Co., Milltown, Ind. By H. D. Baylor.
6604—Methods and Costs of Concentrating Scheelite Ore at the Silver Dike Mill, Mineral Co., Nevada.
6605—Milling Methods and Costs at the Pecos Concentrator of the American Metal Co. Tererro, N. Mex. By H. D. Bemis.
6606—Geophysical Abstracts No. XXXV. By Fred W. Lee.
6611—Small Scale Placer Mining Methods. By Chas. F. Jackson and John B. Knaebel.
6612—Gold Mining and Milling Methods and Costs at the Vallecito Western Drift Mine, Angels Camp, Cal. By Don Steffa.
6613—Factors Governing the Selection of the Proper Level Interval in Underground Mines. By Wm. O. Vanderburg.
6614—A Ventilation Study of the Graceton Coal and Coke Co. Mine, Graceton, Pa. By R. D. Currie and E. R. Maize.
6617—Falls of Roof and Coal in Washington Mines. By S. H. Ash.
6618—Accident Experience and Cost in Pennsylvania Anthracite and Bituminous Mines, 1926–1930. By Wm. J. Fene.
6619—Milling Methods and Costs at the Concentrator of the Britannia Mining and Smelting Co., Ltd., Brittania Beach. B. C. By A. C. Munroe and H. A. Pearse.
6620—Geophysical Abstracts No. XXXVI. By Frederick W. Lee.
6621—Milling Methods and Costs at the Hillside Fluorspar Mines, Rosiclaire, Ill. By Edwin C. Reeder.
6622—Employee-Timekeeping System and Mechanical Pay Roll Methods at Britannia Mining and Smelting Co., Ltd., Britannia Beach, B. C. By Albert E. Keller and E. C. Gillingham.
6623—Procedure of the Purchasing and Supply Departments of the Miami Copper Co., Miami, Ariz. By Fred L. Bishop and Albert E. Keller.
6625—Bonuses to Encourage Safe Work and for Work Safely Done. By D. Harrington.
6627—Iron Oxide Pigments and Morta Colors. By R. M. Santmyers.
6629—Mining Laws of Poland. By E. P. Youngman.

Petroleum Field Office, San Francisco:

Recent Articles on Petroleum and Allied Substances.

Governmental, State:

California State Department of Public Works, Sacramento:

"California Highways and Public Works."

California State Division of Fish and Game, San Francisco:

"California Fish and Game."

California State Library, Sacramento:

"News Notes."

Colorado Bureau of Mines, Denver:

Annual Reports.

Idaho Bureau of Mines and Geology, Moscow:

Pamphlet No. 37—The Recovery of Gold from Its Ores. By A. W. Fahrenwald.

Idaho Inspector of Mines, Boise:

Annual Reports.

Illinois State Geological Survey, Urbana:

Reports, Press Bulletins, etc.
R. I. No. 25—Illinois Mineral Industry in 1931.

Kansas State Geological Survey, Lawrence:

Bulletin 18—The Geology of Wallace County, Kansas. By M. K. Elias.

Nebraska Geological Survey, Lincoln:

Second Series.

Bulletin 1—The Stratigraphy of the Pennsylvania System in Nebraska. By G. E. Condra.

Bulletin 2—The Fusulinidae of the Pennsylvania System in Nebraska. By Dunbar and Condra.

Bulletin 3—Correlation of the Pennsylvania Beds in the Platte and Jones Point Sections of Nebraska. By G. E. Condra.

Bulletin 4—Deep Wells of Nebraska. By Condra, Schramm and Lugin.

Bulletin 5—Brachiopoda of the Pennsylvania System in Nebraska. By Dunbar and Condra.

Bulletin 6—Correlation of the Big Blue Series in Nebraska. By Condra and Upp.

New Jersey Department of Conservation and Development, Trenton:

Bulletin 37—The Mineral Industry of New Jersey for 1930.

New Mexico State Bureau of Mines and Mineral Resources, Socorro:

Circular No. 5—Gold Mining and Gold Deposits in New Mexico. By C. H. Wells and T. P. Wooten.

Ohio Geological Survey, Columbus:

Fourth Series.

Bulletin 36—The Lawrence Clay of Lawrence County.

South Dakota Geological and Natural History Survey, Vermillion:

R. I. No. 11, Parts 1 and 2—Sand and Gravel Deposits in Potter and Faulk Counties. By E. P. Rothrock and R. V. Newcomb.

Tennessee State Division of Geology, Nashville:

Bulletin 38—The Stratigraphy of the Central Basin of Tennessee. By R. S. Bassler.

Bulletin 41—Preliminary Report on the Foraminifera of Tennessee. By J. A. Cushman.

Texas Bureau of Economic Geology, Austin:

Nos. 3038, 3042, Parts 1 and 2—The Geology of the Glass Mountains, Texas. By P. B. King and R. E. King.

Virginia Geological Survey, Richmond:

Bulletin 34—Geology and Mineral Resources of the Roanoke Area. By H. P. Woodward.

Governmental, Foreign:

Argentina Direccion General de Minas y Geologia, Buenos Aires:

Publications.

South Australia Department of Mines, Adelaide:

Annual Reports, Mining Reviews, etc.

British Columbia Minister of Mines, Victoria:

Annual Reports, etc.

Canadian Institute of Mining and Metallurgy, Montreal:

Transactions.

Canada Department of Mines, Ottawa:

Memoir 169—Geology and Mineral Deposits of a Part of Southeastern Manitoba. By J. F. Wright.

Summary Reports.

Annual Reports.

No. 724—Investigations in Ore Dressing and Metallurgy.

No. 729—Clay and Shale Resources of Turner Valley and Nearby Districts. By W. G. Worcester.

No. 2294—Oil and Gas in Eastern Canada. By G. S. Hume.
No. 2309—Gold Occurrences of Canada. Summary Account. By H. C. Cooke and W. A. Johnston.

Geological Survey of Great Britain, London:
Memoirs, Geologic Maps, etc.

Museo de Historia Natural de Montevideo, Uruguay:
Anales.

New Zealand Geological Survey Branch, Wellington:
Reports.

Nova Scotia Department of Public Works and Mines, Halifax:
Annual Reports.

Ontario Department of Mines, Toronto:
Annual Reports.

Quebec Bureau of Mines, Quebec:
Reports.

Secretaria de Industria, Comercio y Trabajo, Mexico, D. F.:
Boletin Minero.
Boletin del Petroleo.

Transvaal Chamber of Mines, Johannesburg:
Publications.

Societies and Educational Institutions:

Academy of Natural Sciences of Philadelphia:
Proceedings.

American Association of Petroleum Geologists, Tulsa, Oklahoma:
Bulletins.

American Geographical Society of New York:
"Geographical Review."

American Journal of Science, New Haven, Conn.

American Philosophical Society, Philadelphia:
Proceedings.

Australia Museum, Sydney:
Records.

California Academy of Sciences, San Francisco:
Proceedings.

Canadian Institute of Mining and Metallurgy, Montreal:
"Canadian Mining and Metallurgical Bulletin."

Colorado College Publication, Colorado Springs.

Colorado Scientific Society, Denver:
Proceedings.

Commonwealth Club, San Francisco:
Journals.

Economic Geology, Lancaster, Pa.

Field Museum of Natural History, Chicago:
Geological Series.

Geological Society of America, Columbia University, New York:
Bulletin.

Institution of Mining and Metallurgy, London:
Bulletins, Transactions.

Instituto Geologico de Mexico, Mexico, D. F.:
Boletin Num. 51—Zonas Mineras de las Estadas de Jalisco y Nayarit.

Library of Congress, Washington, D. C.:
Monthly Check List of State Publications.

Mineralogical Society of America, Menasha, Wisconsin:
"The American Mineralogist."

Mining and Metallurgical Society of America, New York:
Bulletins.

New York Academy of Sciences, New York:
Annals, etc.

New York State Museum, Albany:
Publications.

Northwest Scientific Association, Cheney, Wash.:
"Northwest Science."

Pennsylvania State College, State College:
Bulletins.

Philippine Journal of Science, Manila.

Sierra Club, San Francisco:
Bulletin.

Southern California Academy of Sciences, Los Angeles:
Bulletins.

Seismological Society of America, Stanford University:
Bulletins.

Texas Technological College, Lubbock:
Bulletins.

Society of Economic Paleontologists and Mineralogists, Fort Worth:
"Journal of Paleontology."

University of California, Berkeley.

Publications in Geology:
Vol. 22, No. 1—A Contact Section on the Mokelumne River, California. By A. A. Fitch.

Publications in Geography:
Vol. 6, No. 1—Toward a Theory of the Morphologic Significance of Turbulence in the Flow of Water in Streams. By J. B. Leighly.

Western Society of Engineers, Evanston, Ill.:
Journals.

Washington State College, Pullman:
Vol. 14, No. 10—Hand Methods of Placer Mining and Placer Mining Districts of Washington and Oregon. By G. E. Ingersoll.

Books:

Composite Catalog of Oil Refinery and Natural Gasoline Plant Equipment, 1932. Published by Gulf Publishing Co., Houston.

Flotation Index. Compiled by Great Western Electro-Chemical Co., San Francisco.

Quarry, Mine and Plant Practice. Published by McGraw Hill Publishing Co., Inc.

Use of Calol Asphalt in Asphaltic Concrete Pavement Construction. By Standard Oil Co. of California.

John Hays Hammond Public Mining Library:

Books Added:

Beryllium. By Siemens-Konzern, translated by Rimbach and Michel.
Modern Divining Rods. By R. J. Stanschi.
Spanish and Indian Place Names of California. By N. Van de Grift Sanchez. 1914.

Maps:

U. S. Geologic Topographic Maps:

California:

Arroyo Sequit Quadrangle, Los Angeles County.
Delta Farms Quadrangle, Fresno County.
East Elk Hills Quadrangle, Kern County.
Gosford Quadrangle, Kern County.
Humphreys Quadrangle, Los Angeles County.
Las Flores Quadrangle, Los Angeles County.
Russell Valley Quadrangle, Los Angeles County.
Seminole Quadrangle, Los Angeles County.
West Elk Hills Quadrangle, Kern County.
West of Lenthent Quadrangle, Fresno County.
Wheatville Quadrangle, Fresno County.

Idaho:

Bayhorse Quadrangle, Custer, County.

Missouri:

Mexico Quadrangle.

Montana:

National Bison Range.

New Mexico:

Magdalena District, Sacorro County.

North Dakota:

Flora Quadrangle.

Oklahoma:

Fairfax Quadrangle.
Ripley Quadrangle.
Strand Quadrangle.

Oregon:

Three Sisters Quadrangle.

Texas:

Beaumont Quadrangle.
Camp Springs Quadrangle.
Dundee Quadrangle, Archer County.
Junction Quadrangle.
Manning Quadrangle.
Orange Quadrangle.
Paint Rock Quadrangle.
Rule Quadrangle.
Springtown Quadrangle.
Stacy Quadrangle.
Tow Quadrangle.
Valley Wills Quadrangle, Dimmit County.
Voss Quadrangle.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Architect and Engineer, San Francisco.

Asbestos, Philadelphia, Pennsylvania.
Asbestology, Canadian Asbestos Co., Montreal, Canada.
Brick and Clay Record, Chicago.
California Mining Journal, Nevada City.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Caterpillar, San Leandro, California.
Chemical Engineering and Mining Review, Melbourne, Australia.
Chemical and Metallurgical Engineering, New York City.
Commerce Reports, Washington, D. C.
Colorado School of Mines, Golden, Colorado.
Cooper-Bessemer Monthly, Grove City, Pennsylvania.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Industrial Employment Information Bulletin, Washington, D. C.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pa.
Mining Congress Journal, Washington, D. C.
Mining and Industrial Record, Vancouver, B. C.
Mining Journal, Phoenix, Arizona.
Mining Journal, London.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining Truth, Spokane, Washington.
Monthly Review of Business Conditions, San Francisco.
National Sand and Gravel, Washington, D. C.
Oil, Philadelphia, Pa.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Petroleum Age, Chicago.
Petroleum Times, London, E. C. 2.
Petroleum World, Los Angeles.
Pit and Quarry, Chicago.
Queensland Government Mining Journal, Brisbane, Australia.
Record, Associated Oil Co., San Francisco.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Through the Ages, Baltimore.

Newspapers.

The following papers are received and kept on file in the library:

Amador Dispatch, Jackson, California.
Barstow Printer, Barstow, California.
Beaumont Gazette, Beaumont, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
California Oil World, Los Angeles, California.
Colusa Daily Sun, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Exeter Sun, Exeter, California.
Goldfield News, Goldfield, Nevada.
Inland Oil Index, Casper, Wyoming.

Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mojave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
National Industrial Review, San Francisco, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Press, Reno, Nevada.
Oil Refinery News, Bayonne, New Jersey.
Petroleum Press, Taft, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by the Bureau to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of Mining in California was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of Mining in California, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of Mining in California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-one years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have often been limited, many of the reports and bulletins mentioned were printed in limited editions which are now entirely exhausted.

Copies of such publications are available, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; Bankers Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas, Santa Barbara; Santa Paula; Coalinga; Taft; Bakersfield. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained by addressing any of the above offices and enclosing the requisite amount in the case of publications that have a list price. Only coin, stamps or money orders should be sent, and it will be appreciated if remittance is made in this manner rather than by personal check.

The prices noted include delivery charges to all parts of the United States. Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
**Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks	----
**Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.	$1.00
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, Biennial Period, 1913–1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper	.50
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pages, paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913–1914, Fletcher Hamilton, 1915:	—
A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period, 1915–1916. Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper	.50
**Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper	----
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper	.65
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915–1916, Fletcher Hamilton, 1917:	
A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report, Biennial Period 1917–1918, Fletcher Hamilton:	
Mines and Mineral Rosources of Nevada County, 270 pp., paper	.75
Mines and Mineral Resources of Plumas County, 188 pp., paper	.50
Mines and Mineral Resources of Sierra County, 144 pp., paper	.50

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth	$1.75
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, **May, **June, July, August, September, October, **November, December, 1922	Free
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923	Free
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, **July, October, 1924, per copy	.25
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties	.25
April, 1925, Mines and Mineral Resources of Calaveras. Merced, San Joaquin, Stanislaus and Ventura Counties	.25
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	.25
**October, 1925, Mines and Mineral Resources of Siskiyou, san Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	.25
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties	.25
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties	.25
October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	.25
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island	.25
April, 1927, Mines and Mineral Resources of Amador and Solano Counties	.25
July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	.25
October, 1927, Mines and Mineral Resources of Mono County	.25
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County	.25
April, 1928, Mines and Mineral Resources of Mariposa County	.25
**July 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties	.25
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
**January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	----
April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	.25
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties	.25
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties	.25
Chapters of Twenty-sixth Report of the State Mineralogist 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California	.25
April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	.25
July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	.25

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary)	$0.25
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California', Walter W. Bradley. Published quarterly:	
January, 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative effects in Concrete	.25
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifer of the Kreyenhagen Shale. Geology of Santa Cruz Island	.25
July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	.25
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activity in Inyo and Mono Counties in July, 1931	.25
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite	.25
April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	.25
Subscription, $1.00 in advance (by calendar year, only).	
Chapters of State Oil and Gas Supervisor's Report:	
Summary of Operations—California Oil Fields, July, 1918, to March, 1919 (one volume)	Free
Summary of Operations—California Oil Fields. Published monthly, beginning April, 1919:	
**April, **May, **June, **July, **August, **September, **October, **November, **December, 1919	----
**January, **February, **March, **April, **May, **June, **July, **August, **September, **October, **November, **December, 1920	----
January, **February, **March, April, **May, **June, **July, August, **September, **October, **November, **December, 1921	Free
January, February, March, April, May, **June, **July, **August, September, **October, **November, December, 1922	Free
January, **February, **March, **April, May, **June, **July, August, September, **October, November, December, 1923	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1924	Free
January, February, March, April, May, June, **July, August, September, October, November, December, 1925	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1926	Free
January, February, March, April, May, June, July, August, September, October, November, December, 1927	Free
January, February, March, April, **May, June, July, **August, September, **October, **November, **December, 1928	Free
January, February, March, April, May, June, July-August-September, October-November-December, 1929	Free
January-February-March, April-May-June, July-August-September, October-November-December, 1930	Free
(Published quarterly beginning July, 1929.)	
January-February-March, April-May-June, July-August-September, 1931	Free

BULLETINS

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 1. A Description of Some Desiccated Human Remains, by Winslow Anderson. 1888. 41 pp., 6 illustrations	----
**Bulletin No. 2. Methods of Mine Timbering, by W. H. Storms. 1894, 58 pp., 75 illustrations	----
**Bulletin No. 3. Gas and Petroleum Yielding Formations of Central Valley of California, by W. L. Watts. 1894, 100 pp., 13 illustrations, 4 maps	----
**Bulletin No. 4. Catalogue of Californian Fossils, by J. G. Cooper, 1894, 73 pp., 67 illustrations. (Part I was published in the Seventh Annual Report of the State Mineralogist, 1887.)	----
**Bulletin No. 5. The Cyanide Process, 1894, by Dr. A. Scheidel. 140 pp., 46 illustrations	----
**Bulletin No. 6. California Gold Mill Practices, 1895, by E. B. Preston, 85 pp., 46 illustrations	----
**Bulletin No. 7. Mineral Production of California, by Counties, for the year 1894, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 8. Mineral Production of California, by Counties, for the year 1895, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 9. Mine Drainage, Pumps, etc., by Hans C. Behr. 1896, 210 pp., 206 illustrations	----
**Bulletin No. 10. A bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by Anthony W. Vogdes. 1896, 121 pp.	----
**Bulletin No. 11. Oil and Gas Yielding Formations of Los Angeles, Ventura and Santa Barbara Counties, by W. L. Watts. 1897, 94 pp., 6 maps, 31 illustrations	----
**Bulletin No. 12. Mineral Production of California, by Counties, for 1896, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 13. Mineral Production of California, by Counties, for 1897, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 14. Mineral Production of California, by Counties, for 1898, by Charles G. Yale	----
**Bulletin No. 15. Map of Oil City Fields, Fresno County, by John H. Means. 1899	----
**Bulletin No. 16. The Genesis of Petroleum and Asphaltum in California, by A. S. Cooper. 1899, 39 pp., 29 illustrations	----
**Bulletin No. 17. Mineral Production of California, by Counties, for 1899, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 18. Mother Lode Region of California, by W. H. Storms. 1900, 154 pp., 49 illustrations	----
**Bulletin No. 19. Oil and Gas Yielding Formations of California, by W. L. Watts. 1900, 236 pp., 60 illustrations, 8 maps	----
**Bulletin No. 20. Synopsis of General Report of State Mining Bureau, by W. L. Watts. 1901, 21 pp. This bulletin contains a brief statement of the progress of the mineral industry in California for the four years ending December, 1899	----
**Bulletin No. 21. Mineral Production of California by Counties, by Charles G. Yale. 1900. Tabulated sheet	----
**Bulletin No. 22. Mineral Production of California for Fourteen Years, by Charles G. Yale. 1900. Tabulated sheet	----
Bulletin No. 23. The Copper Resources of California, by P. C. DuBois, F. M. Anderson, J. H. Tibbits and G. A. Tweedy. 1902, 282 pp., 69 illustrations, 9 maps	$0.50
**Bulletin No. 24. The Saline Deposits of California, by G. E. Bailey. 1902, 216 pp., 99 illustrations, 5 maps	----
**Bulletin No. 25. Mineral Production of California, by Counties, for 1901, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 26. Mineral Production of California for the Past Fifteen Years, by Charles G. Yale. 1902. Tabulated sheet	----
**Bulletin No. 27. The Quicksilver Resources of California, by William Forstner. 1903, 273 pp., 144 illustrations, 8 maps	----
**Bulletin No. 28. Mineral Production of California for 1902, by Charles G. Yale. Tabulated sheet	----

12—97834

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 29. Mineral Production of California for Sixteen Years, by Charles G. Yale. 1903. Tabulated sheet	----
**Bulletin No. 30. Bibliography Relating to the Geology, Paleontology and Mineral Resources of California, by A. W. Vogdes. 1903, 290 pp.	----
**Bulletin No. 31. Chemical Analyses of California Petroleum, by H. N. Cooper. 1904. Tabulated sheet	----
**Bulletin No. 32. Production and Use of Petroleum in California, by Paul W. Prutzman. 1904, 230 pp., 116 illustrations, 14 maps	----
**Bulletin No. 33. Mineral Production of California, by Counties, for 1903, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 34. Mineral Production of California for Seventeen Years, by Charles G. Yale. 1904. Tabulated sheet	----
**Bulletin No. 35. Mines and Minerals of California, by Charles G. Yale. 1904, 55 pp., 20 county maps. Relief map of California	----
**Bulletin No. 36. Gold Dredging in California, by J. E. Doolittle. 1905. 120 pp., 66 illustrations, 3 maps	----
**Bulletin No. 37. Gems, Jewelers' Materials, and Ornamental Stones of California, by George F. Kunz. 1905, 168 pp., 54 illustrations	----
**Bulletin No. 38. Structural and Industrial Materials of California, by Wm. Forstner, T. C. Hopkins, C. Naramore and L. H. Eddy. 1906, 412 pp., 150 illustrations, 1 map	----
**Bulletin No. 39. Mineral Production of California, by Counties, for 1904, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 40. Mineral Production of California for Eighteen Years, by Charles G. Yale. 1905. Tabulated sheet	----
**Bulletin No. 41. Mines and Minerals of California for 1904, by Charles G. Yale. 1905, 54 pp., 20 county maps	----
**Bulletin No. 42. Mineral Production of California, by Counties, 1905, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 43. Mineral Production of California for Nineteen Years, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 44. California Mines and Minerals for 1905, by Charles G. Yale. 1907, 31 pp., 20 county maps	----
**Bulletin No. 45. Auriferous Black Sands of California, by J. A. Edman. 1907. 10 pp.	----
**Bulletin No. 46. General Index of Publications of the California State Mining Bureau, by Charles G. Yale. 1907, 54 pp.	----
**Bulletin No. 47. Mineral Production of California, by Counties, 1906, by Charles G. Yale. Tabulated sheet	----
**Bulletin No. 48. Mineral Production of California for Twenty Years, by Charles G. Yale. 1906	----
**Bulletin No. 49. Mines and Minerals of California for 1906, by Charles G. Yale. 34 pp.	----
Bulletin No. 50. The Copper Resources of California, 1908, by A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorne and J. A. Edman. 366 pp., 74 illustrations. (Revised edition.)	$1.00
**Bulletin No. 51. Mineral Production of California, by Counties, 1907, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 52. Mineral Production of California for Twenty-one Years, by D. H. Walker. 1907. Tabulated sheet	----
**Bulletin No. 53. Mineral Production of California for 1907, with County Maps, by D. H. Walker. 62 pp.	----
**Bulletin No. 54. Mineral Production of California, by Counties, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 55. Mineral Production of California for Twenty-two Years, by D. H. Walker, 1908. Tabulated sheet	----
**Bulletin No. 56. Mineral Production for 1908, with County Maps and Mining Laws of California, by D. H. Walker. 78 pp.	----
**Bulletin No. 57. Gold Dredging in California, by W. B. Winston and Chas. Janin. 1910, 312 pp., 239 illustrations, 10 maps	----
**Bulletin No. 58. Mineral Production of California, by Counties, by D. H. Walker. 1909. Tabulated sheet	----

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 59. Mineral Production of California for Twenty-three Years, by D. H. Walker. 1909. Tabulated sheet	----
**Bulletin No. 60. Mineral Production for 1909, with County Maps and Mining Laws of California, by D. H. Walker. 94 pp.	----
**Bulletin No. 61. Mineral Production of California, by Counties, for 1910, by D. H. Walker. Tabulated sheet	----
**Bulletin No. 62. Mineral Production of California for Twenty-four Years, by D. H. Walker. 1910. Tabulated sheet	----
**Bulletin No. 63. Petroleum in Southern California, by P. W. Prutzman. 1912, 430 pp., 41 illustrations, 6 maps	----
**Bulletin No. 64. Mineral Production for 1911, by E. S. Boalich. 49 pp.	----
**Bulletin No. 65. Mineral Production for 1912, by E. S. Boalich. 64 pp.	----
**Bulletin No. 66. Mining Laws of the United States and California. 1914, 89 pp.	----
**Bulletin No. 67. Minerals of California, by Arthur S. Eakle. 1914, 226 pp.	----
**Bulletin No. 68. Mineral Production for 1913, with County Maps and Mining Laws, by E. S. Boalich. 160 pp.	----
**Bulletin No. 69. Petroleum Industry of California, with Folio of Maps (18 by 22), by R. P. McLaughlin and C. A. Waring. 1914, 519 pp., 13 illustrations, 83 figs. [18 plates in accompanying folio.]	----
**Bulletin No. 70. Mineral Production for 1914, with County Maps and Mining Laws. 184 pp.	----
**Bulletin No. 71. Mineral Production for 1915, with County Maps and Mining Laws, by Walter W. Bradley. 193 pp., 4 illustrations	----
**Bulletin No. 72. The Geologic Formations of California, by James Perrin Smith. 1916, 47 pp.	----
**Reconnaissance Geologic Map (of which Bulletin 72 is explanatory), in 23 colors. Scale: 1 inch = 12 miles. Mounted	----
**Bulletin No. 73. First Annual Report of the State Oil and Gas Supervisor of California, for the Fiscal Year 1915–16, by R. P. McLaughlin. 278 pp., 26 illustrations	----
Bulletin No. 74. Mineral Production of California in 1916, with County Maps, by Walter W. Bradley. 179 pp., 12 illustrations	Free
**Bulletin No. 75. United States and California Mining Laws. 1917, 115 pp., paper	----
Bulletin No. 76. Manganese and Chromium in California, by Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring. 1918, 248 pp., 51 illustrations, 5 maps, paper	$0.50
Bulletin No. 77. Catalogue of Publications of California State Mining Bureau, 1880–1917, by E. S. Boalich. 44 pp., paper	Free
Bulletin No. 78. Quicksilver Resources of California, with a Section on Metallurgy and Ore-Dressing, by Walter W. Bradley, 1919. 389 pp., 77 photographs and 42 plates (colored and line cuts), cloth	1.50
Bulletin No. 79. Magnesite in California, by Walter W. Bradley. 1925, 147 pp., 62 photographs, 11 line cuts and maps, cloth	1.00
†Bulletin No. 80. Tungsten, Molybdenum and Vanadium in California. (In preparation.)	
†Bulletin No. 81. Foothill Copper Belt of California. (In preparation.)	
**Bulletin No. 82. Second Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1916–1917, by R. P. McLaughlin. 1918, 412 pp., 31 illustrations, cloth	----
Bulletin No. 83. California Mineral Production for 1917, with County Maps, by Walter W. Bradley. 179 pp., paper	Free
**Bulletin No. 84. Third Annual Report of the State Oil and Gas Supervisor, for the Fiscal Year 1917–1918, by R. P. McLaughlin. 1918, 617 pp., 28 illustrations, cloth	----
**Bulletin No. 85. Platinum and Allied Metals in California, by C. A. Logan, 1919. 10 photographs, 4 plates, 120 pp., paper	----
Bulletin No. 86. California Mineral Production for 1918, with County Maps, by Walter W. Bradley. 1919. 212 pp., paper	Free

BULLETINS—Continued

Asterisks (**) indicate the publication is out of print.

	Price
**Bulletin No. 87. Commercial Minerals of California, with notes on their uses, distribution, properties, ores, field tests, and preparation for market, by W. O. Castello. 1920, 124 pp., paper	----
Bulletin No. 88. California Mineral Production for 1919, with County Maps, by Walter W. Bradley. 1920, 204 pp., paper	Free
**Bulletin No. 89. Petroleum Resources of California, with Special Reference to Unproved Areas, by Lawrence Vander Leck. 1921, 12 figures, 6 photographs, 6 maps in pocket, 186 pp., cloth	----
Bulletin No. 90. California Mineral Production for 1920, with County Maps, by Walter W. Bradley. 1921, 218 pp., paper	Free
Bulletin No. 91. Minerals of California, by Arthur S. Eakle. 1923, 328 pp. cloth	$1.00
**Bulletin No. 92. Gold Placers of California, by Chas. S. Haley. 1923 167 pp., 36 photographs and 7 plates (colored and line cuts, also geologic map), cloth	----
Bulletin No. 93. California Mineral Production for 1922, by Walter W. Bradley. 1923, 188 pp., paper	Free
**Bulletin No. 94. California Mineral Production for 1923, by Walter W. Bradley. 1924, 162 pp., paper	----
Bulletin No. 95. Geology and Ore Deposits of the Randsburg Quadrangle, by Carlton D. Hulin. 1925, 152 pp., 49 photographs, 13 line cuts, 1 colored geologic map, cloth	2.00
**Bulletin No. 96. California Mineral Production for 1924, by Walter W. Bradley. 1925, 173 pp., paper	----
**Bulletin No. 97. California Mineral Production for 1925, by Walter W. Bradley. 1926, 172 pp., paper	----
Bulletin No. 98. American Mining Law, by A. H. Ricketts, 1931, 811 pp., flexible leather	2.00
Bulletin No. 99. Clay Resources and Ceramic Industry of California, by Waldemar Fenn Dietrich. 1928, 383 pp., 70 photos, 12 line cuts including maps, cloth	1.50
**Bulletin No. 100. California Mineral Production for 1926, by Walter W. Bradley. 1927, 174 pp., paper	----
**Bulletin No. 101. California Mineral Production for 1927, by Henry H. Symons. 1928, 311 pp., paper	----
Bulletin No. 102. California Mineral Production for 1928, by Henry H. Symons. 1929, 210 pp., paper	Free
Bulletin No. 103. California Mineral Production for 1929, by Henry H, Symons, 1930. 231 pp., paper	Free
**Bulletin No. 104. Bibliography of the Geology and Mineral Resources of California, to the end of 1929, by Solon Shedd, 1931. (Preliminary Edition only, subject to revision)	----
Bulletin No. 105. Mineral Production in California for 1930 and Directory of Producers	Free
Bulletin No. 106. Manner of Locating and Holding Mineral Claims in California (with forms)	.25
Bulletin No. 107. Mineral Production in California for 1931 and Directory of Producers	Free

PRELIMINARY REPORTS

Asterisks (**) indicate the publication is out of print.

	Price
**Preliminary Report No. 1. Notes on Damage by Water in California Oil Fields, December, 1913. By R. P. McLaughlin. 4 pp.	----
**Preliminary Report No. 2. Notes on Damage by Water in California Oil Fields, March, 1914. By R. P. McLaughlin. 4 pp.	----
Preliminary Report No. 3. Manganese and Chromium, 1917. By E. S. Boalich. 32 pp.	Free
Preliminary Report No. 4. Tungsten, Molybdenum and Vanadium. By E. S. Boalich and W. O. Castello, 1918. 34 pp. Paper	Free
Preliminary Report No. 5. Antimony, Graphite, Nickel, Potash, Stontium and Tin. By E. S. Boalich and W. O. Castello, 1918. 44 pp. Paper	Free
**Preliminary Report No. 6. A Review of Mining in California During 1919. By Fletcher Hamilton, 1920. 43 pp. Paper	----
**Preliminary Report No. 7. The Clay Industry in California. By E. S. Boalich, W. O. Castello, E. Huguenin, C. A. Logan, and W. B. Tucker, 1920. 102 pp. 24 illustrations. Paper	----
**Preliminary Report No. 8. A Review of Mining in California During 1921, with Notes on the Outlook for 1922. By Fletcher Hamilton, 1922. 68 pp. Paper	----

MISCELLANEOUS PUBLICATIONS

**First Annual Catalogue of the State Museum of California, being the collection made by the State Mining Bureau during the year ending April 16, 1881. 350 pp.	----
**Catalogue of books, maps, lithographs, photographs, etc., in the library of the State Mining Bureau at San Francisco, May 15, 1884. 19 pp.	----
**Catalogue of the State Museum of California, Volume II, being the collection made by the State Mining Bureau from April 16, 1881, to May 5, 1884. 220 pp.	----
**Catalogue of the State Museum of California, Volume III, being the collection made by the State Mining Bureau from May 15, 1884, to March 31, 1887. 195 pp.	----
**Catalogue of the State Museum of California, Volume IV, being the collection made by the State Mining Bureau from March 30, 1887, to August 20, 1890. 261 pp.	----
**Catalogue of the Library of the California State Mining Bureau, September 1, 1892. 149 pp.	----
**Catalogue of West North American and Many Foreign Shells with Their Geographical Ranges, by J. G. Cooper. Printed for the State Mining Bureau, April, 1894	----
**Report of the Board of Trustees for the four years ending September, 1900. 15 pp. Paper	----
Bulletin. Reconnaissance of the Colorado Desert Mining District. By Stephen Bowers, 1901. 19 pp. 2 illustrations. Paper	Free
Commercial Mineral Notes. A monthly mimeographed sheet, beginning April, 1923	Free

MAPS

Register of Mines With Maps.

Asterisks (**) indicate the publication is out of print.

	Price
Register of Mines, with Map, Amador County	$0.25
Register of Mines, with Map, Butte County	.25
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
**Register of Mines, with Map, Inyo County	----
**Register of Mines, with Map, Kern County	----
**Register of Mines, with Map, Lake County	----
**Register of Mines, with Map, Mariposa County	----
**Register of Mines, with Map, Nevada County	----
**Register of Mines, with Map, Placer County	----
**Register of Mines, with Map, Plumas County	----
**Register of Mines, with Map, San Bernardino County	----
**Register of Mines, with Map, San Diego County	----
Register of Mines, with Map, Santa Barbara County (1906)	.25
**Register of Mines, with Map, Shasta County	----
**Register of Mines, with Map, Sierra County	----
**Register of Mines, with Map, Siskiyou County	----
**Register of Mines, with Map, Trinity County	----
**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.25
Register of Oil Wells, with Map, Los Angeles City (1906)	.35

OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----
Geological Map of California, 1916. Scale 1 inch equals 12 miles. As accurate and up-to-date as available data will permit as regards topography and geography. Shows railroads, highways, post offices and other towns. First geological map that has been available since 1892, and shows geology of entire state as no other map does. Geological details lithographed in 23 colors. Unmounted	.75
Mounted	2.00
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt, accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly.)	.25

OIL FIELD MAPS

These maps are revised from time to time as development work advances and ownerships change.

	Price
Map No. 1—Sargent, Santa Clara County	$0.50
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	.75
Map No. 3—Santa Maria, including Casmalia and Lompoc	.75
Map No. 4—Whittier-Fullerton, including Olinda, Brea Canyon, Puente Hills, East Coyote and Richfield	.75
Map No. 5—Whittier-Fullerton, including Whittier, West Coyote and Montebello	.75
Map No. 6—Salt Lake, Los Angeles County	.75
Map No. 7—Sunset and San Emidio and Kern County	.75
Map No. 8—South Midway and Buena Vista Hills, Kern County	.75
Map No. 9—North Midway and McKittrick, Kern County	.75
Map No. 10—Belridge and McKittrick, Kern County	.75
Map No. 11—Lost Hills and North Belridge, Kern County	.75
Map No. 12—Devils Den, Kern County	.75
Map No. 13—Kern River, Kern County	.75
Map No. 14—Coalinga, Fresno County	1.00
Map No. 15—Elk Hills, Kern County	.75
Map No. 16—Ventura-Ojai, Ventura County	.75
Map No. 17—Santa Paula-Sespe Oil Fields, Ventura County	.75
Map No. 18—Piru-Simi-Newhall Oil Fields	.75
Map No. 19—Arroyo Grande, San Luis Obispo County	.75
Map No. 20—Long Beach Oil Field	1.25
Map No. 21—Portion of District 4, Showing Boundaries of Oil Fields, Kern and Kings counties	.75
Map No. 21A—Portion Kern and Kings counties	.75
Map No. 22—Portion of District 3, Showing Oil Fields, Santa Barbara County	.75
Map No. 23—Portion of District 2, Showing Boundaries of Oil Fields, Ventura County	.75
Map No. 24—Portion of District 1, Showing Boundaries of Oil Fields, Los Angeles and Orange counties	.75
Map No. 26—Huntington Beach Oil Field	.75
Map No. 27—Santa Fe Springs Oil Field	.75
Map No. 28—Torrance, Los Angeles County	.75
Map No. 29—Dominguez, Los Angeles County	.75
Map No. 30—Rosecrans, Los Angeles County	.75
Map No. 31—Inglewood, Los Angeles County	.75
Map No. 32—Seal Beach, Los Angeles and Orange counties	.75
Map No. 33—Rincon, Ventura County	.75
Map No. 34—Mt. Poso, Kern County	.75
Map No. 35—Round Mountain, Kern County	.75
Map No. 36—Kettleman Hills, Kings County	1.25
Map No. 37—Montebello, Los Angeles County	.75
Map No. 38—Whittier, Los Angeles County	.75
Map No. 39—West Coyote, Los Angeles and Orange counties	.75
Map No. 40—Elwood, Santa Barbara County	.75
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75
Map. No. 43—Capitan, Santa Barbara County	.75
Map No. 44—Mesa, Santa Barbara County	.75

DETERMINATION OF MINERAL SAMPLES

Samples (limited to three at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

INDEX

o

97834 3-33 2500

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES

CORDIALLY INVITES YOU TO VISIT ITS VARIOUS DEPARTMENTS MAINTAINED FOR THE PURPOSE OF FURTHERING THE DEVELOPMENT OF THE

MINERAL RESOURCES OF CALIFORNIA

At the service of the public are the scientific reference library and reading room, the general information bureau, the laboratory for the free determination of mineral samples found in the State, and the largest museum of mineral specimens on the Pacific Coast. The time and attention of the State Mineralogist, as well as that of his technical staff, are also at your disposal.

Office hours: 9 a.m. to 5 p.m. daily.
Saturday, 9 a.m. to 12 m.

WALTER W. BRADLEY,
State Mineralogist.

Third floor, Ferry Building, San Francisco, Cal.
Branch Offices: Bankers Building, Los Angeles; State Office Building, Sacramento; Chamber of Commerce, Redding; Bank of Italy Building, Bakersfield; San Marcos Building, Santa Barbara; Taft, Coalinga and Santa Paula.